# QUANTIFICATION OF QUALITATIVE DEFECTS FOR AUTOMOBILE CUSTOMERS

**A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF**

**Bachelor of Technology**

**Metallurgical and Materials Engineering Department**


**By**

**MUKUND AGARWAL (110MM0345)**

**ABHISHEK SAHOO (110MM0105)**




**DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING**

**NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA**


**May, 2014**

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**MUKUND AGARWAL (110MM0345)**

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**UNDER THE GUIDANCE OF**
**PROF. SWAPAN KUMAR KARAK**




**DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING**

**NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA**


**May, 2014**

**National Institute of Technology**

**Rourkela**

# Certificate

This is to certify that the thesis entitled "**Quantification of Qualitative Defects for Automobile Customers**" being submitted by **Mukund Agarwal (110MM0345), Abhishek Sahoo (110MM0105)**, for the partial fulfillment of the requirements of Bachelor of Technology degree in Metallurgical and Materials engineering is a bona fide thesis work done by them under my supervision during the academic year 2013-2014, in the Department of Metallurgical and Materials Engineering, National Institute of Technology Rourkela, India.

The results presented in this thesis have not been submitted elsewhere for the award of any other degree or diploma.

Date: **(Prof. Swapan Kumar Karak)**

Metallurgical and Materials Engineering
National Institute of Technology Rourkela
Rourkela, 769008
Odisha, India

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**Date:**

**Mukund Agarwal (110MM0345)**

**Abhishek Sahoo (110MM0105)**

Bachelors in Technology
Metallurgical and Materials Engineering
National Institute of Technology Rourkela

# CONTENT

# ABSTRACT

Increasing productivity by minimizing the defects is of utmost importance to any steel industry. Cold Rolling Mill plays a very important role due to its very complex processes and the products end use. Deliverance of high quality product to the customer, relentlessly understanding their requirement and regular feedback became the basis for working on this project. During the process where a coil from Hot Strip Mill (HSM) goes into the Pickling Line to Cold Rolling Mill to Batch Annealing to Final Packaging and Dispatch amidst various other processes, it acquires various defects that need to be catered before delivery to the customer. Some defects can be minimized through improvement in maintenance and some are inherent (where CRM is a customer).

The aim of the project is form a quantitative comparative study with the help of profilometer analysis of Raw CRCA, Phospotised CRCA, and Painted CRCA of stainless steel samples. On the basis of comparison, one will be able to conclude upto what severity a particular defect will be passed.

Among the various defects analyzed by profilometer, the Lamination & Gouge Mark are the most severed defects. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 5 – 40 µm for Lamination & 8 – 10 µm for Gouge mark. This shows that these defects are highly prone to customer complaints and often goes for rejection. The difference upto 1 µm are passed without much scrutiny. Anything beyond 1 µm difference calls for action by both manufacturer & customer.

**Keywords:** Cold Rolled Cold Annealed, Annealing, Surface Profilometer, Roughness, Flat product Defects, Automobile Sheets

## 2 | INTRODUCTION

Defects are inherent to any manufacturing industry. A lot of resources and money is spent on minimizing this.

Quantification of Defects helps reject defected pieces and manage mass production with ease. Cold Rolling Mill or CRM is the customer of Automobile Customers. The CRCA coils produced is used in what see as the everyday utility vehicles in the form of 2-Wheeler, 3-Wheeler and Multi Wheelers. Apart from this, they are used in other several industries as well.

The same idea has been implemented, and this project tries to quantify the qualitative defects produced in CRM.

The project is mainly divided into 4 main stages:

1. Collection of samples of different defects of varying severity (Range 1-7).
2. Conducting the profilometer test of Raw CRCA Sample before sending it for Phospotisation.
3. Conducting the Profilometer test of Phospotised sample before sending it for a layer of painting.
4. Conducting the Profilometer test of Painted sample and performing a thorough comparison.

The comparison will help in ascertaining upto what severity a defect can be passed.

## 3.1 | ABOUT PROFILOMETER

Profilometer is an instrument to measure a surface's profile, in order to quantify its roughness. They are categorized as Contact and Non-Contact Profilometer [1].

Optical Profilometer, a non-contact type profilometer has been used in this project to the study the surface's profile. Optical Profile measures height variation. It provides accurate surface measurements, produces high quality three-dimensional surface maps of the object under test.

2D Surface Metrology:

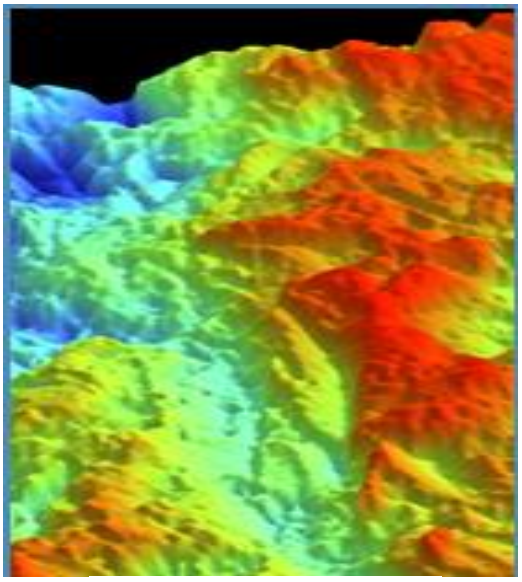


Fig: 3.1.1

Surface metrology is defined as a tool to measures surface roughness by studying surface geometry as shown in fig.

Measuring surface roughness is one of the important concern for a wide range of industries and applications. This includes auto component wear, medical implant efficacy to various other industrial application.

3D Surface Metrology

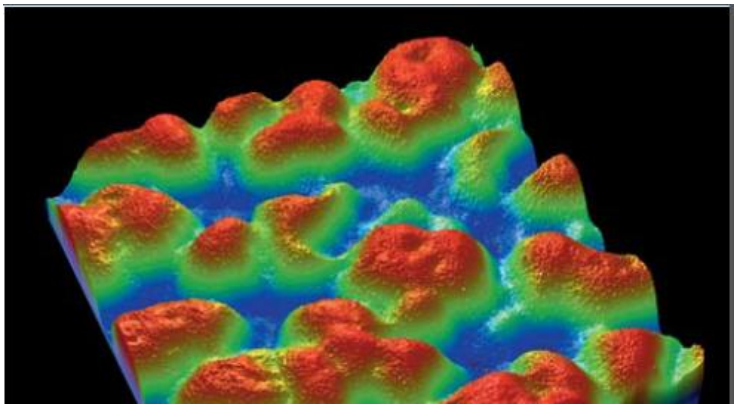


Fig: 3.1.2

3D surface metrology uses 3D surface profilers to provide a 3 dimensional perspective to the surface, Fig: 3.1.2; these 3D surface profilers using the light wavelengths provides more

effective surface imaging and measurement.

3D surface metrology offers the opportunity to get the 3D dimensional perspective compared to cross section analysis from 2D surface analysis.

**Instrument Used:**

Fig: 3.1.3

About Wyko NT9100 Profiler:

Specification: Model - Vecco NT9100,

Magnification – 5X,

Measurement Array – 640 x 480,

Field of View – 1.2 mm.

## 3.2 | Phospotisation

Phosphatisation is a process of treating the steel to create a layer of phosphate on its surface whereby metal phosphate layers are formed on base material which are hardly soluble.

The main areas of application/advantages include:

- ✓ Temporary corrosion protection for steel, when stored for limited period of time.
- ✓ Improving the sliding properties when cold forming steel.
- ✓ Improved powder and paint coating adhesions.

The most common phosphating chemistry include iron phosphate, zinc phosphate, manganese phosphate. The Phosphating may be a 3 or 5 stage process. The 3 stage process takes into account Clean/Phosphate, Rinse, Rinse/Seal and the 5 stage process proceeds as Clean, Rinse, Activated Rinse, Phosphate, Rinse.

The one utilised during these experiments is the Titanium Phosphate.

### 3.3 | Painting

After the Raw CRCA samples have been phosphatised, the samples are subjected to ED. Then 2-3 layers of Spray/other form of Painting is carried out on the CRCA sheets [2]. Different automobiles manufacturers follow different practices accounting for different thickness of layers of paint. This may be followed by an optional layer of lacker to provide optimum finish to the auto components.

Dry Film Thickness

Various coatings are incorporated on the Raw CRCA sample before the end utilisation by the customers in form of Automobiles.

The first layer of painting should have a minimum Dry Film Thickness (DFT). This is equivalent to 30 microns for Spray Painting.

After putting the first layer of spray paint, the sample was put in the oven at the temperature of 105-110º C for 20 minutes for surface drying and optimum finish.

## 4 | IDENTIFYING DEFECTS IN AREAS OF MANUFACTURING PROCESS

The primary input material to the cold rolling complex is hot rolled coils. The cold rolled products are broadly under the categories: (a) annealed coils (b) galvanised coils and (c) cold rolled full hard coils.

The cold rolled products from the CRM Complex are designed to cater to various market segments such as construction, general engineering, automobile, white goods, packaging etc.

### 4.1 | Process within CRM:

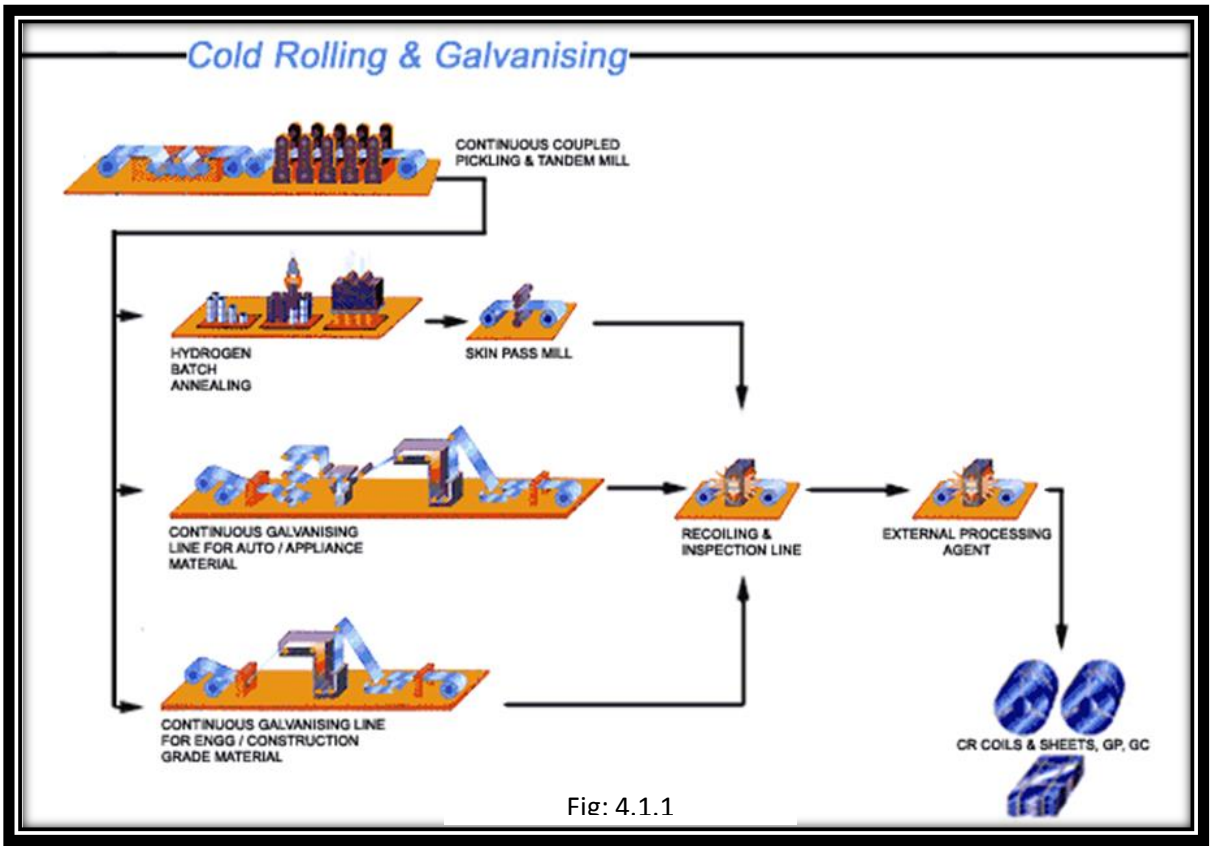



Fig: 4.1.1

- Pickling Line
- Trimmer
- Cold Rolling Mill
- Electrolytic cleaning
- Batch Annealing
- Skin Pass Mill
- Re-Coiling Line
- Packing and Despatch

## 4.2 | DETAILED ANALYSIS

### 4.2.1 | Pickling Line

Fig: 4.2.1

Pickling is an important stage in the process sequence prior to cold rolling. Hot rolled coil serve as the input material for the cold rolling. It has an oxide film or scale on their surface. Pickling eliminates these oxides on the hot rolled strip surface to facilitate subsequent cold rolling. In pickling, the surface of strip is passed through an inorganic acid (hydrochloric or sulphuric acid). The strip is passed through acid bath to remove the oxide.

**Defect due to Poor Pickling**

Under pickling/ Black Patch should not be there. Arises due to pickling stoppages (pickling tank, entry trouble, welder, trimmer, chopper).

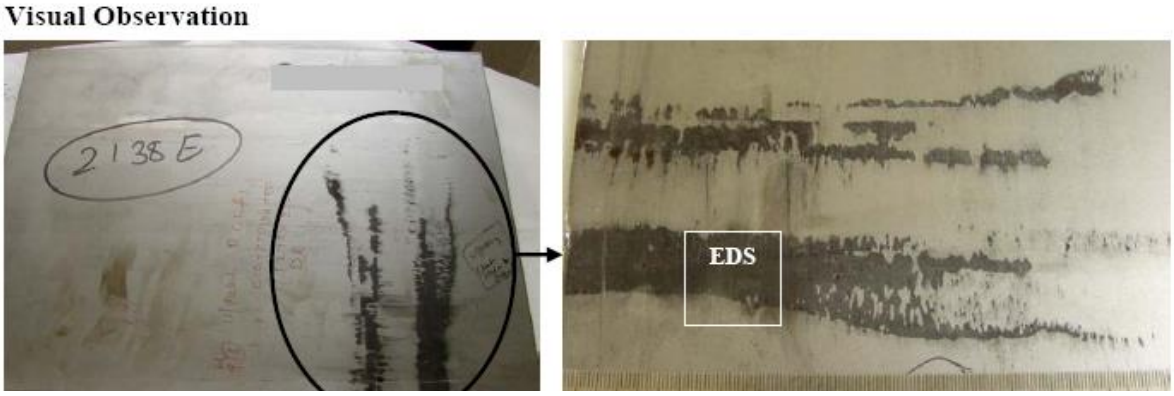



Fig: 4.1.2

## 4.2.2 | Trimmer

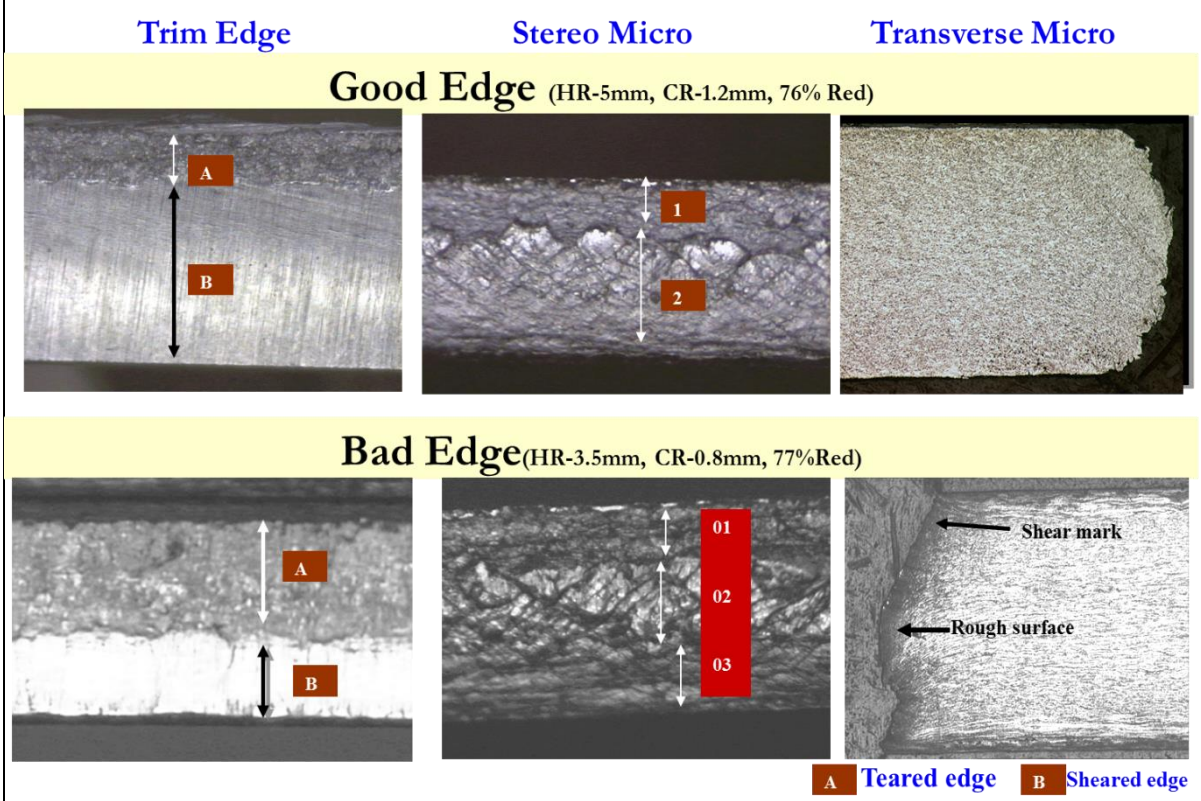



Fig: 4.2.2.1

## Cold Rolling

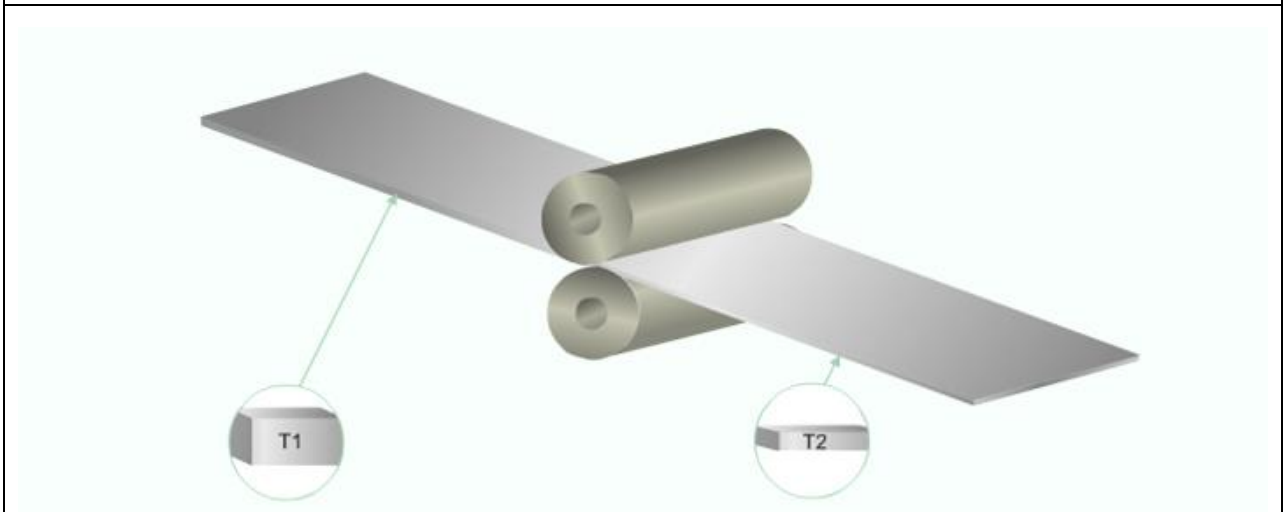
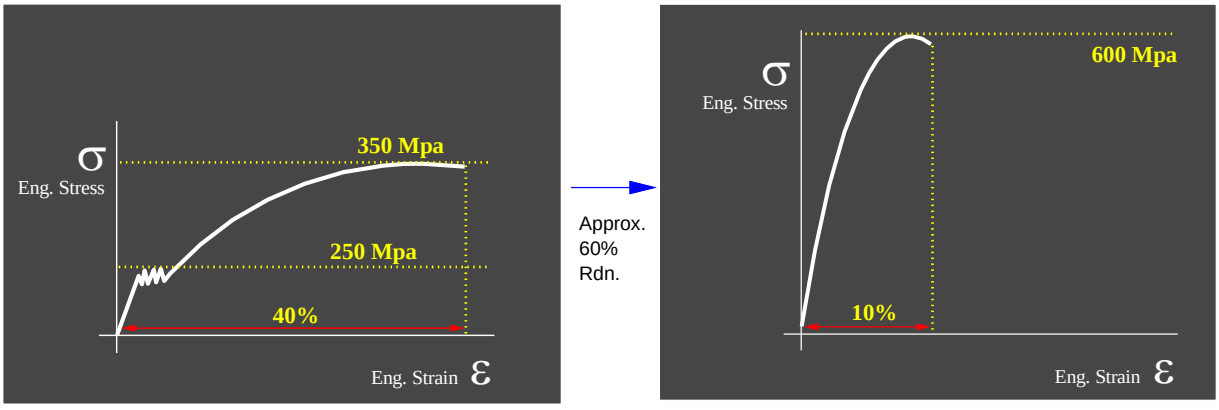



Fig: 4.2.2.2

Cold Rolling is a process by which hot rolled steel is passed through a set of rollers to induce reduction in its thickness. It does not involve external heating as in case of hot rolling. Cold rolling temperature is limited to few hundred Degrees Celsius. Typically the reduction in thickness in nearly 30% to 80%. Unlike hot rolling, width does not change in cold rolling.

| Primary Effects | Secondary Effects |
|---|---|
| • Gauge<br>• Surface Roughness | • Mechanical Properties<br>• Shape<br>• Surface Cleanliness<br>• Surface Defects<br>• Edge Condition<br>• Gauge Profile<br>• Coil Walling<br>• Width |

**Influence on Mechanical Properties**




Hot Rolled Coil

Cold Rolled Coil

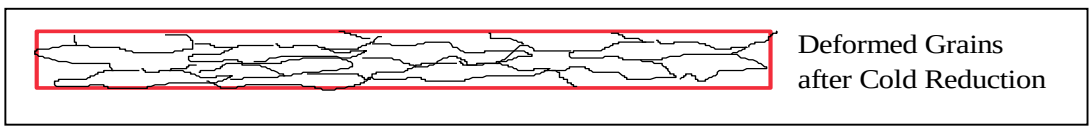



Fig: 4.2.2.3

- Dislocation Density increases substantially with increased cold reduction
- Stored energy increases as this is stored in dislocations
- Higher the stored energy, the greater the driving force for recrystallization

## 4.2.4 | Electrolytic Cleaning

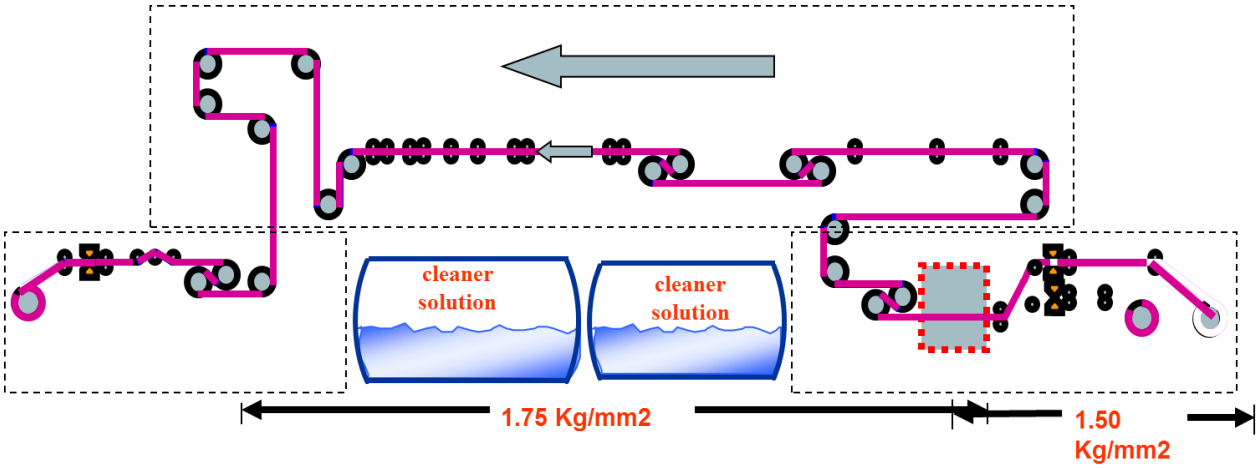



Fig: 4.2.4.1

The aim of Electrolytic Cleaning is:

- ❑ Removal of oil and surface containments
- ❑ Alkaline solution - containing surfactant, suspension agents, anti-foaming agents
- ❑ Rinse
- ❑ Mechanical Brushing

Defects from ECL

- ❑ Alkali Carry Over
- ❑ Scratches
- ❑ Bad Build up
- ❑ Mix-up

**4.2.5 | Batch Annealing**

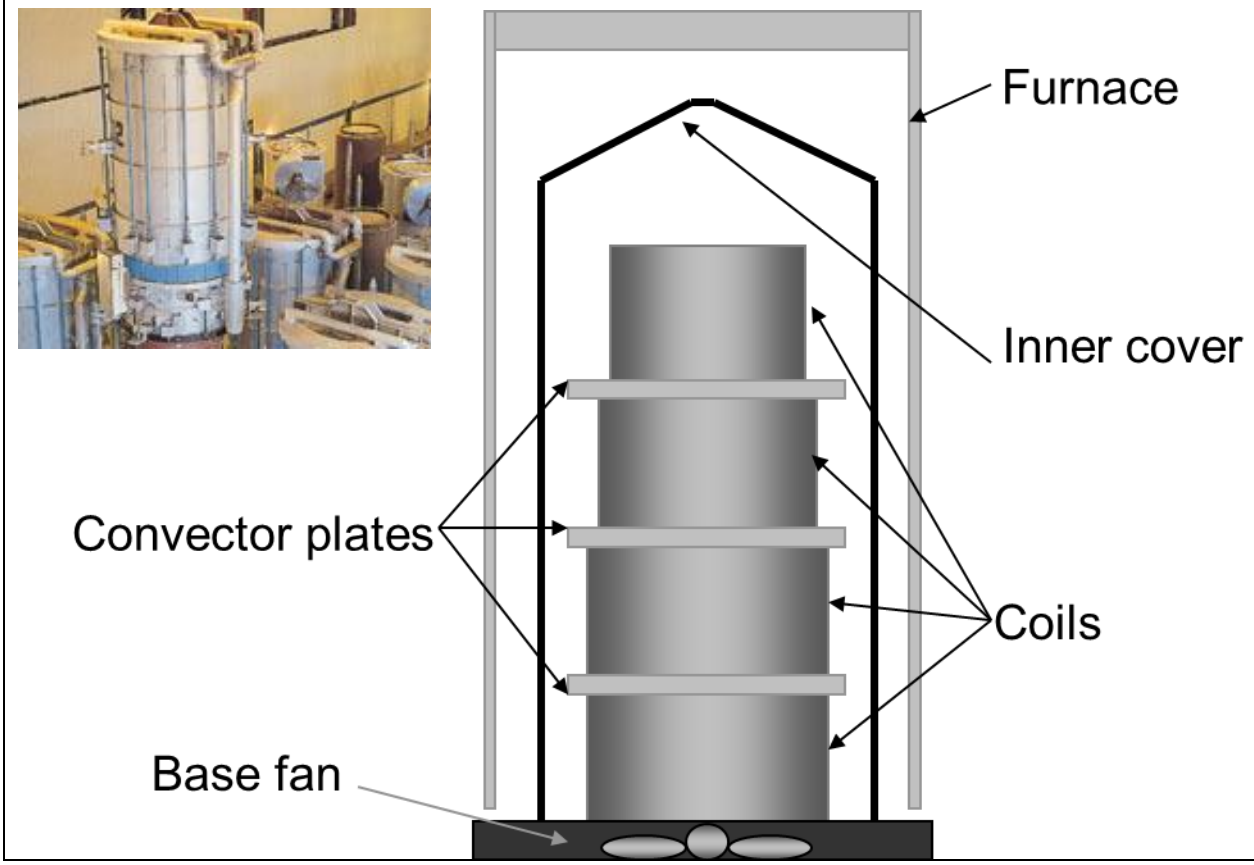
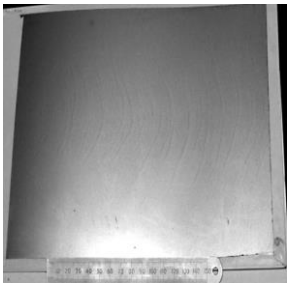
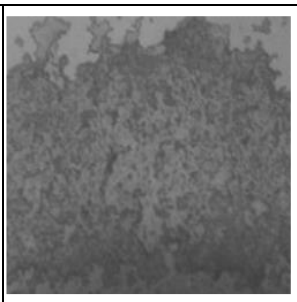
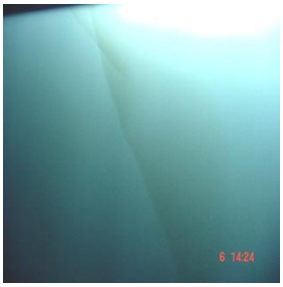
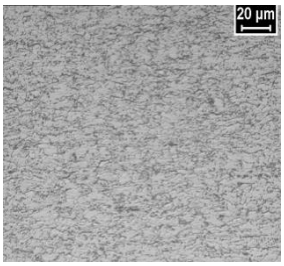



Fig: 4.2.5.1

**Defects from Batch Annealing**

| | | | |
|---|---|---|---|
|  |  |  |  |
| Cause<br>Sticking of adjacent laps during anneal which snatch apart on uncoiling. | Cause<br>Patch resulting due to water leakage. | Cause<br>Oxidation of Coil surface due to de-stacking at High temperature. | Cause<br>Poor Tong design & Poor Handling practice. |
| **Sticker** | **CCSU Patch** | **Brown Shade** | **BAF Tong Mark** |
|  |  |  | |
| Cause<br>Improper Annealing | Cause<br>Poor Centring of Tong<br>Master controller problem<br>ID weld open | Cause<br>-Reduction in hardness of convector plate.<br>Formation of groove in convector plate.<br>-Erosion in convector plate in ID region. | |
| **Poor Mechanical Properties** | **Edge Damage** | **Convector Plate Sticking** | **Carbon Soot** |

**4.2.6 | Skin Pass Mill**

Fig: 4.2.6.1

Single stand 4-hi skin pass mill & electro discharge texturing machine:

Annealed coils are given a small cold reduction (less than 1%) in the SPM. This operation results in the desired surface roughness imparted on the strip surface as per the customer specification. Flatness of the strip is also improved. Control Surface waviness (< 0.6 micron) for better image clarity of auto panels.

Skin Passing is done to:

1. Remove yield point phenomenon
2. Improve and Impart strip flatness and roughness, surface texture
3. Apply RPO

**Defects from SPM and its Causes**

| | | | | |
|---|---|---|---|---|
| 1. SPM Pinch Mark<br><br>Portion of strip folding over through the rolls leaving a corresponding mark on the roll surface which then imprints onto the strip. | 2. Feather Mark<br><br>Uneven work on the strip during temper rolling.<br><br>Over rolling of the strip edges. | 3. Rubbing Mark<br><br>While uncoiling due to tension mismatch | 4. SPM Roll Mark<br><br>Work Roll Damage / Debris | 5. Brown Patch<br><br>High Temperature of coil<br><br>TA carry over & improper oiling |
| 6. SPM Reel Mark | 7. SPM Dent | 8. SPM Scratch | 9. SPM Shape | 10. Black Spot |

## 5 | EXPERIMENTAL DETAILS

**Experimentation:**

A total of 40 samples cut in the size of 20 cm x 15 cm are taken for the experiment. A two dimensional (2-D), three dimensional (3-D), X, Y Profile are generated for each sample for each of the three cases – Raw CRCA sample, Phospotised Sample, After Painted sample. A scanned image for each of the 3 cases is also taken to have a naked eye observation. The following "Scanned Images" for each of the 3 cases gives a brief idea how they look from the naked eye:

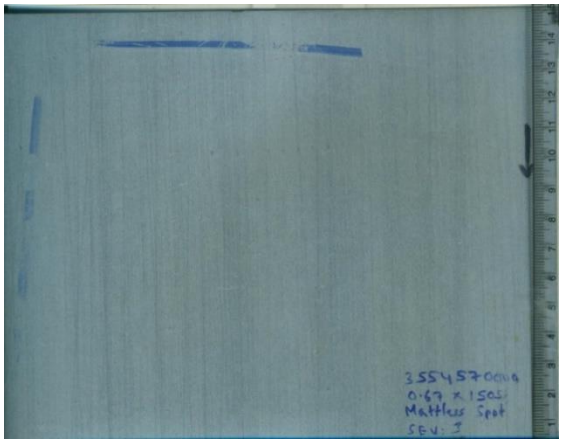


Fig 5.1: Raw CRCA Sample (20 cm x 15 cm)

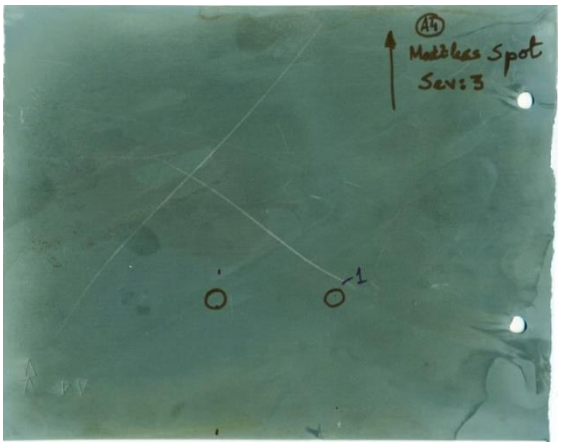



Fig 5. 2: Phospotised CRCA Sample (20 cm x 15 cm)

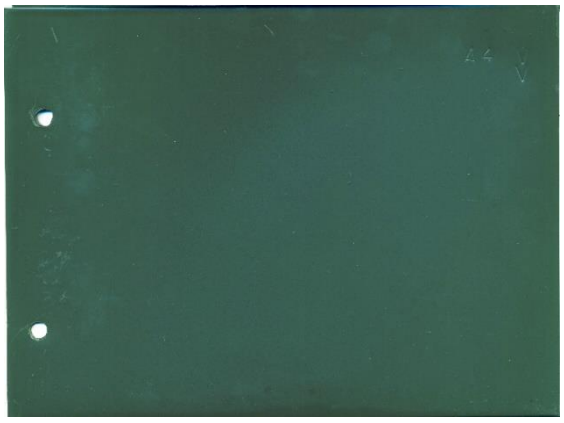


Fig 5.3: Painted CRCA Sample (20 cm x 15 cm)

The layer of Phosphate is of the order of 1-2 microns and the layer of paint is the order of 30 microns. A similar profilometer test is conducted on the in-market automobile sample. The total thickness include the phosphate is of the order of 100 – 130 microns.

The following gives an idea of the 2-D & 3-D figure generated by the profilometer.

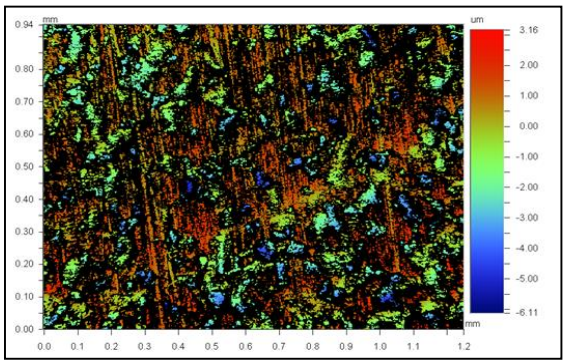


Fig 5.4: 2-D Interactive Display for a defected sample.

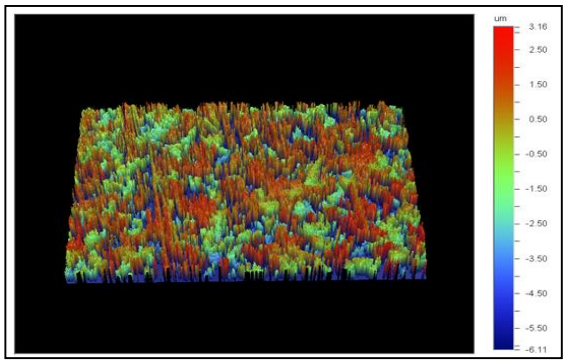


Fig 5.5: 3-D Interactive Display for a defected

The following figure shows the X & Y Profile of the CRCA sample.

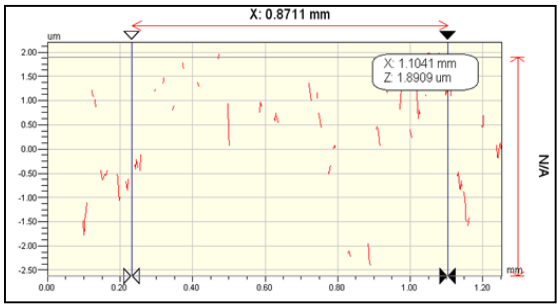



Fig 5.6: X-Profile of the CRCA sample

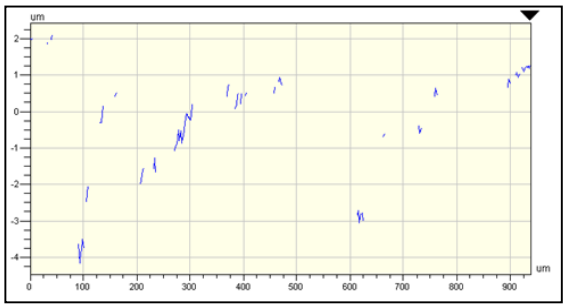


Fig 5.7: Y-Profile of the CRCA sample

Similar Cup Test was carried out for another set of samples collected separately to check for failure of the samples.

Experimental analysis of all the defect against the available severity has been carried out.

# 5.1 | DEFECT: MATTLESS SPOT

**Definition:**

Matteless spot are caused by carbon soot, dirt or iron fines on strip pickup by the roll in certain areas while rolling in Skin Pass Mill. This results in insufficient transfer of matte to the strip surface. This insufficient transfer of matte on strip surface is called as Matteless spot. The following are the severity of Mattless Spot collected for experimental analysis.

## SEVERITY – 2 | 3 |4 | 5

COIL ID: 3601411000 DEFECT: MATTLESS SPOT SEVERITY: 2

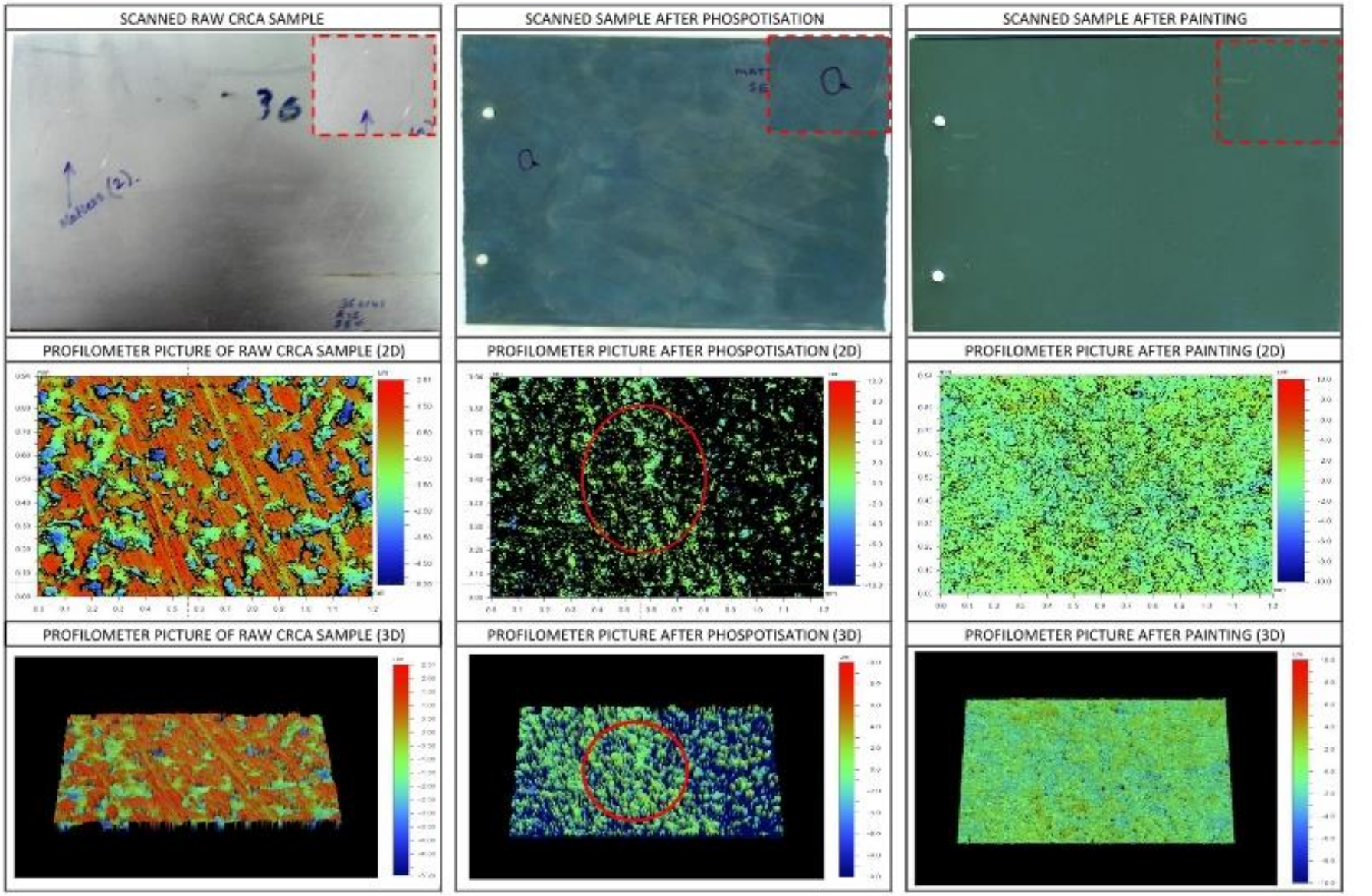
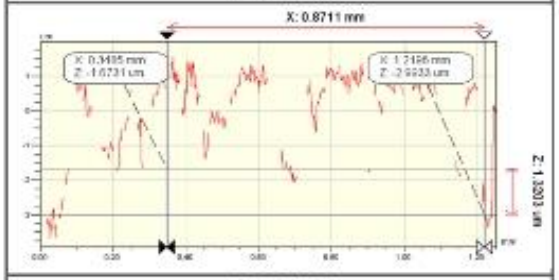
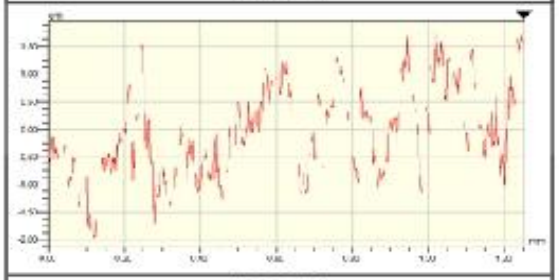
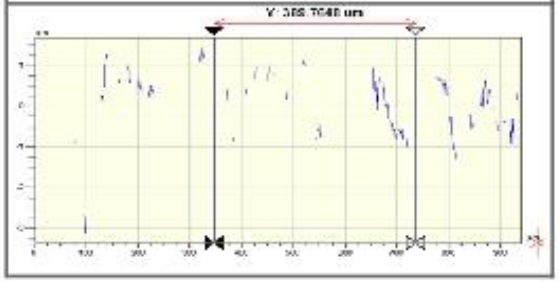
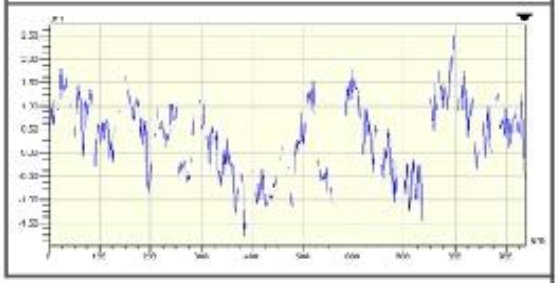



Fig: 5.1.1

COIL ID: 3601411000 | DEFECT: MATTLESS SPOT | SEVERITY: 2

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.67 mm | YIELD STRENGTH (YS): 146 Pa | ULTIMATE TENSILE STRENGTH: 300 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 4.72 um | DEPTH AFTER PHOSPOTISATION | 2.49 um | DEPTH AFTER PAINTING | 3.71 um |

ECV SAMPLE

Mattless Spot of Severity 2 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect

The Roughness of the unaffected area of the sample after painting is 3.45 um, showing the values are comparable to the roughness of defect after painting.

Fig: 5.1.2

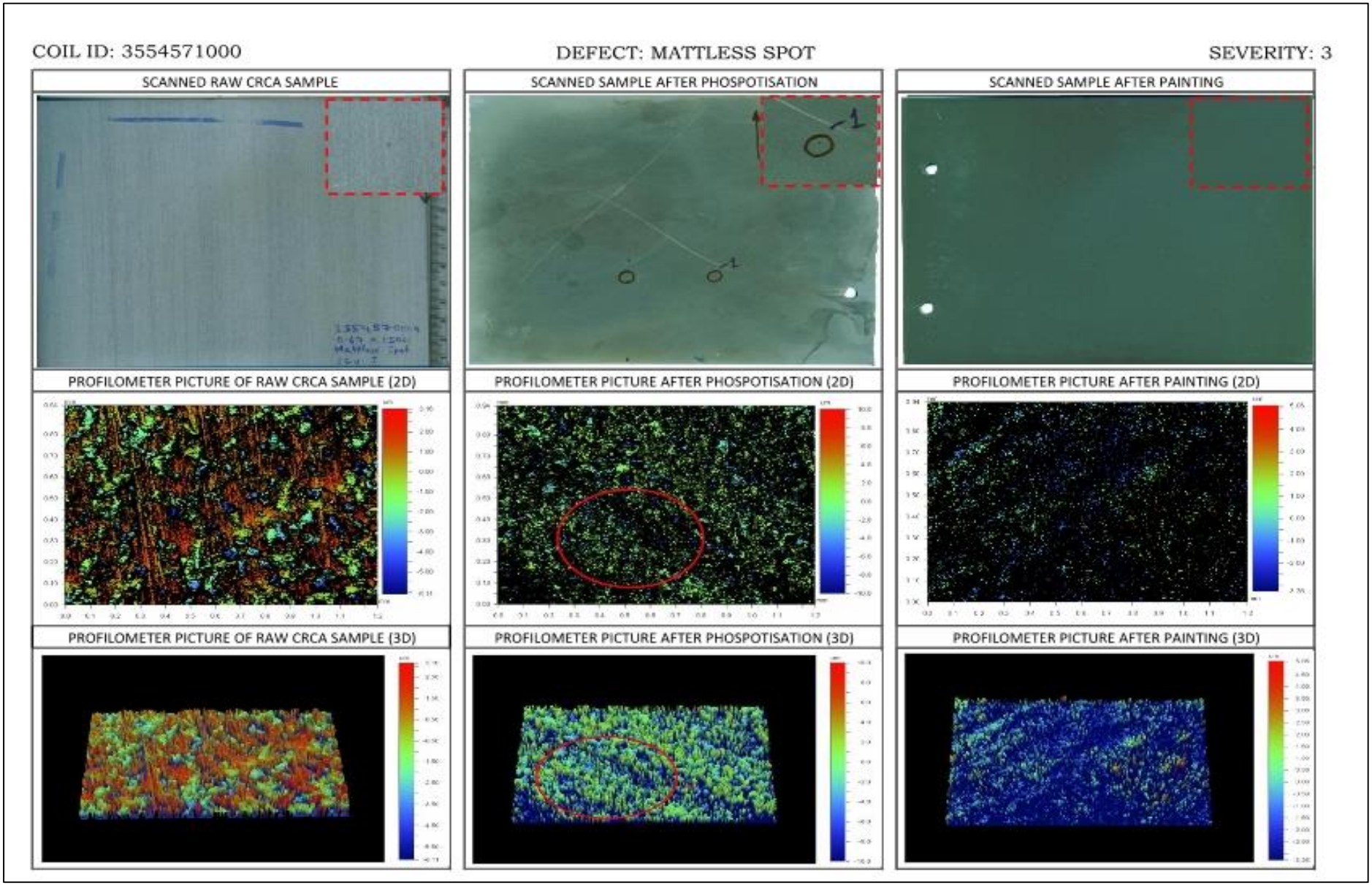
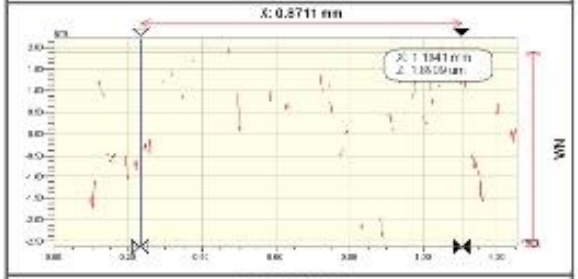
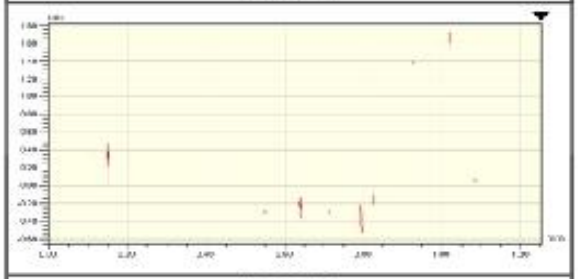
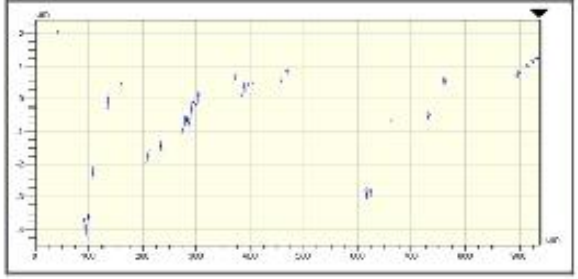
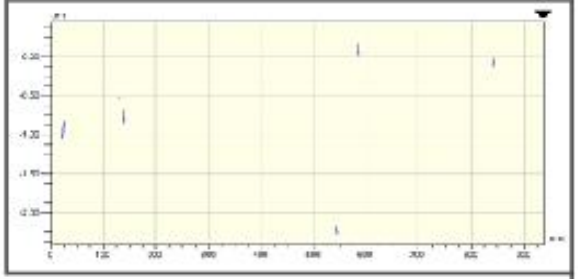

COIL ID: 3554571000
DEFECT: MATTLESS SPOT
SEVERITY: 3
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.1.3

COIL ID: 3554571000 DEFECT: MATTLESS SPOT SEVERITY: 3

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.67 mm | YIELD STRENGTH (YS): 152 Pa | ULTIMATE TENSILE STRENGTH: 310 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 4.38 um | DEPTH AFTER PHOSPOTISATION | 3.37 um | DEPTH AFTER PAINTING | 2.25 um |

ECV SAMPLE

Mattless Spot of Severity 3 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect

The Roughness of the unaffected area of the sample after painting is 2.88 um, showing the values are comparable to the roughness of defect after painting.

Fig: 5.1.4

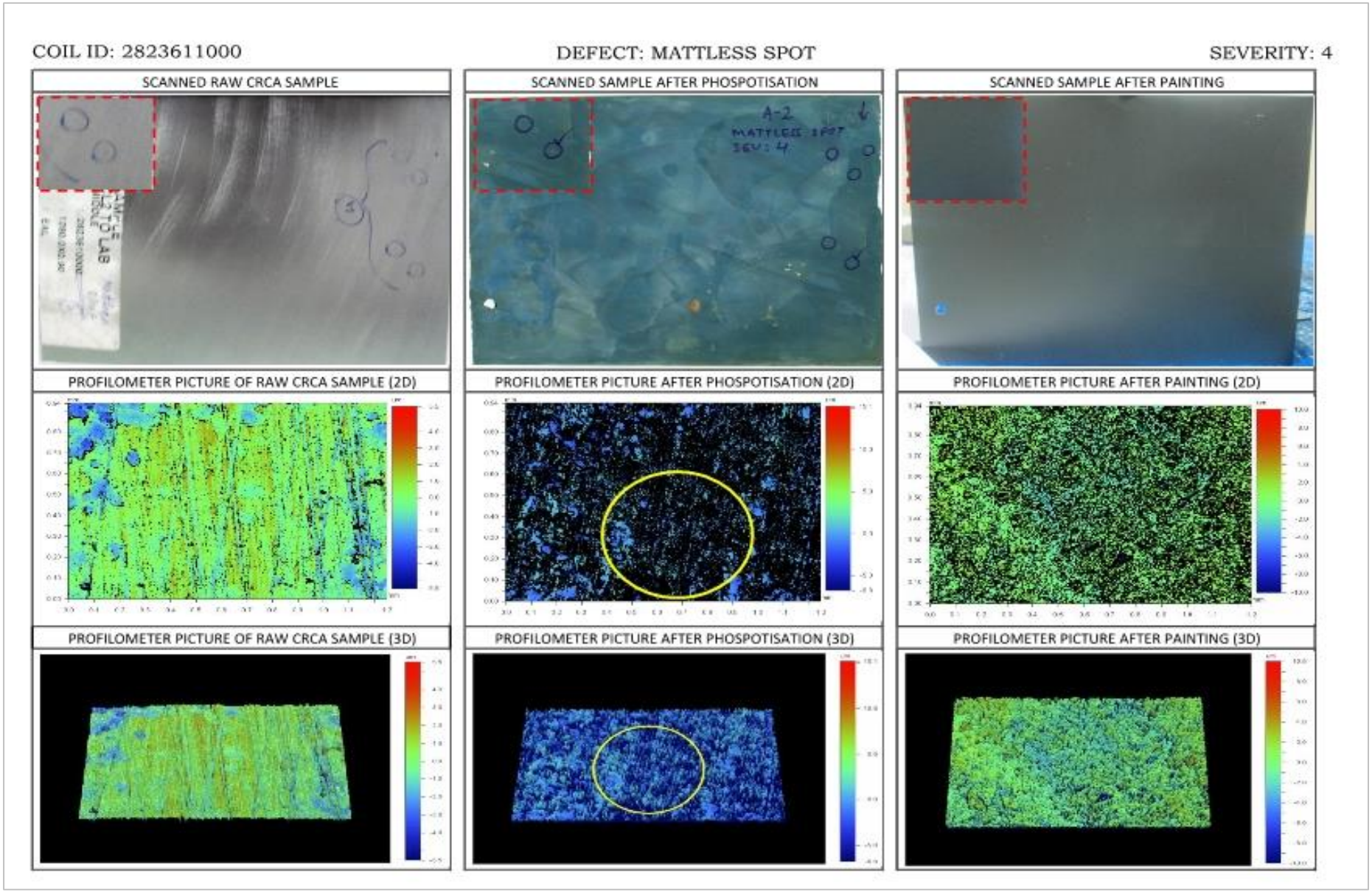
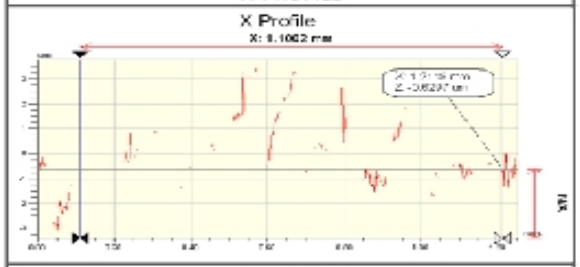
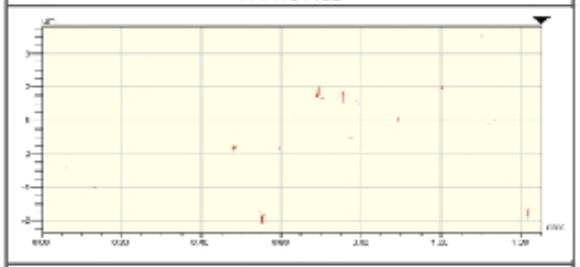
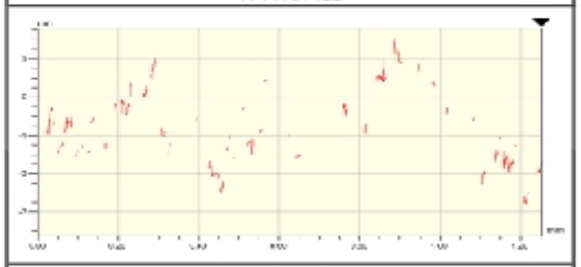
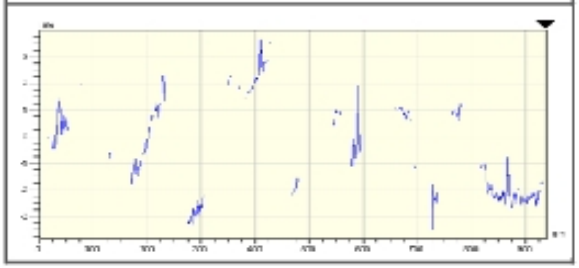
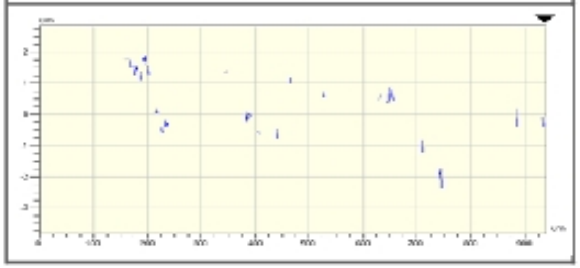
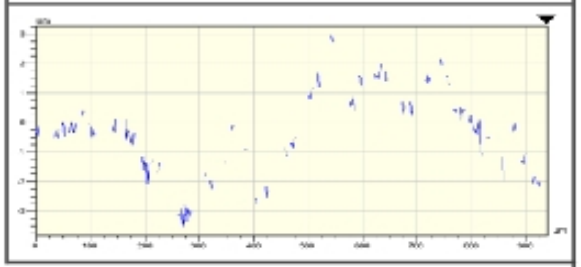

COIL ID: 2823611000
DEFECT: MATTLESS SPOT
SEVERITY: 4
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.1.5

COIL ID: 2612021000 DEFECT: ROLL MARK SEVERITY: 4

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 2.30 mm | YIELD STRENGTH (YS): 137 Pa | ULTIMATE TENSILE STRENGTH: 275 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.21 um | DEPTH AFTER PHOSPOTISATION | 5.61 um | DEPTH AFTER PAINTING | 4.92 um |

ECV SAMPLE

Roll Mark/Dent of Severity 4 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect

The Roughness of the unaffected area of the sample after painting is 3.64 um, showing the values are incomparable to the roughness of defect after painting.

Page No: 37

Fig: 5.1.6

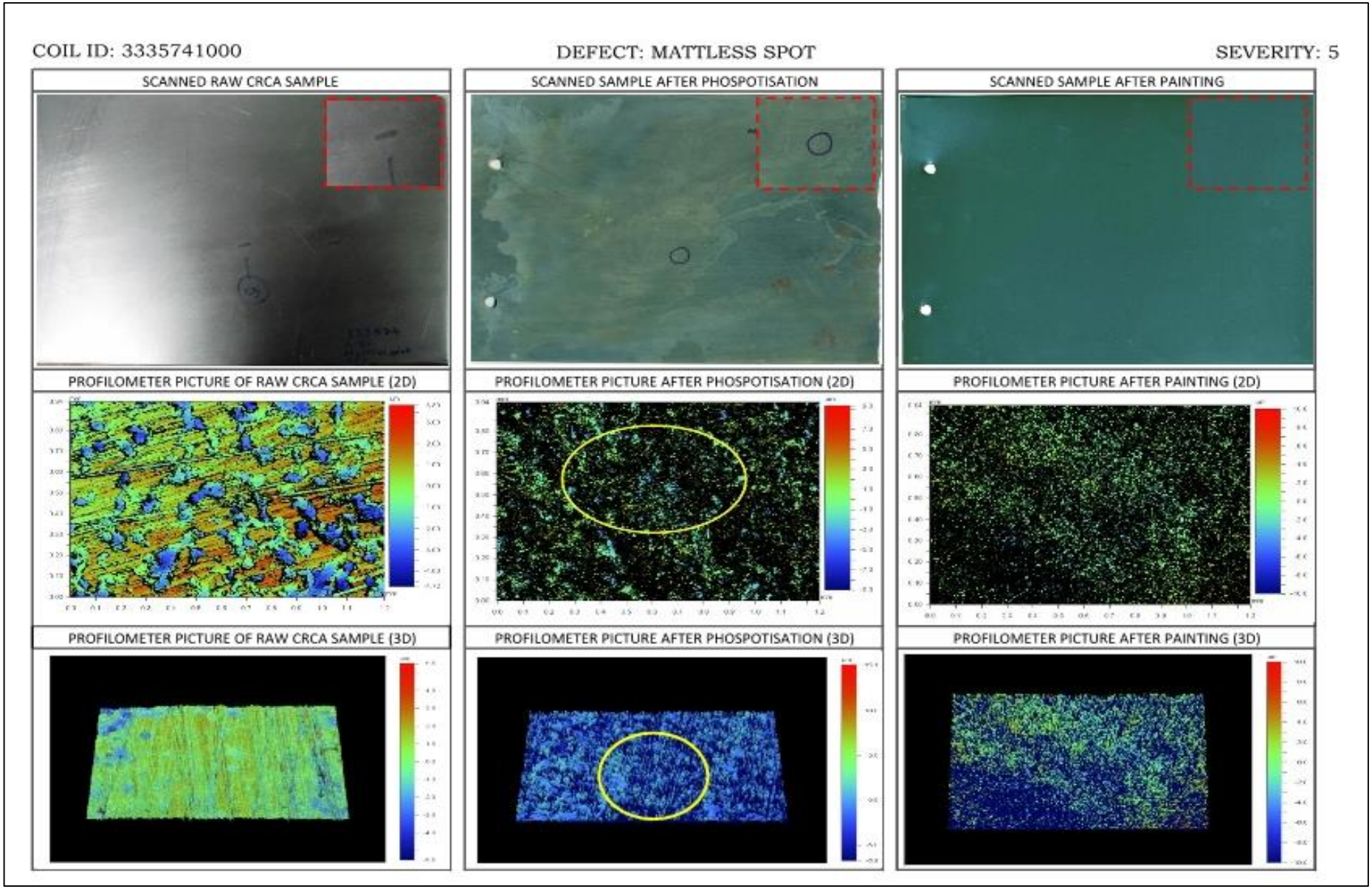
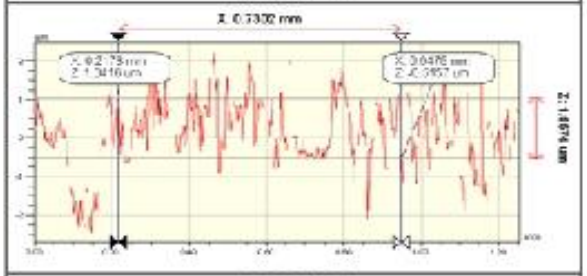
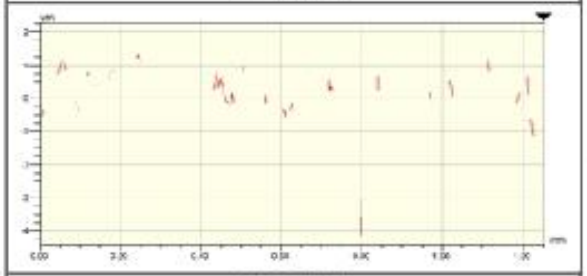
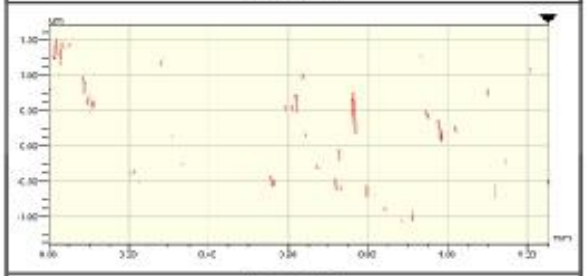
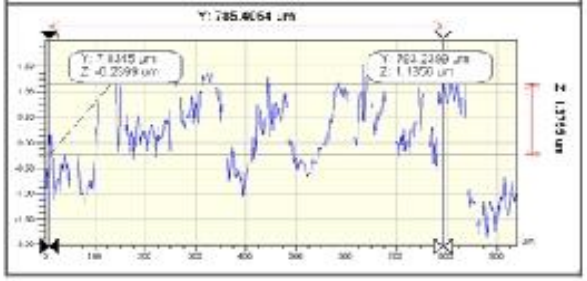
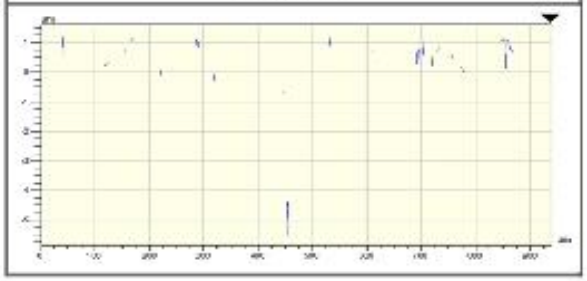
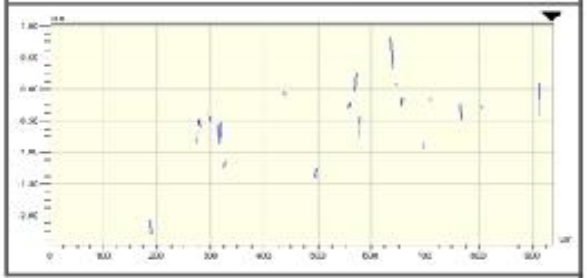

COIL ID: 3335741000
DEFECT: MATTLESS SPOT
SEVERITY: 5
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.1.7

COIL ID: 3335741000 DEFECT: MATTLESS SPOT SEVERITY: 5

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.9 mm | YIELD STRENGTH (YS): 153 Pa | ULTIMATE TENSILE STRENGTH: 308 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.77 um | DEPTH AFTER PHOSPOTISATION | 5.88 um | DEPTH AFTER PAINTING | 2.82 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Mattless Spot of Severity 5 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 2.80 um, showing the values are comparable to the roughness of defect after painting. |

Fig: 5.1.8

# 5.2 | LAMINATION

Definition

This is the slag and oxidized metallic inclusions at the surface of the internal pipe due to solidification shrinkage prevent welding during hot rolling. This defect is similar to sliver but the peeling surface is more extensive.

Causes

-This defect may arise from exposed blowholes. When surface have oxidized and fail to weld up during hot rolling.
-Inadequate dropping of slab.

## SEVERITY – 4 | 6 | 7

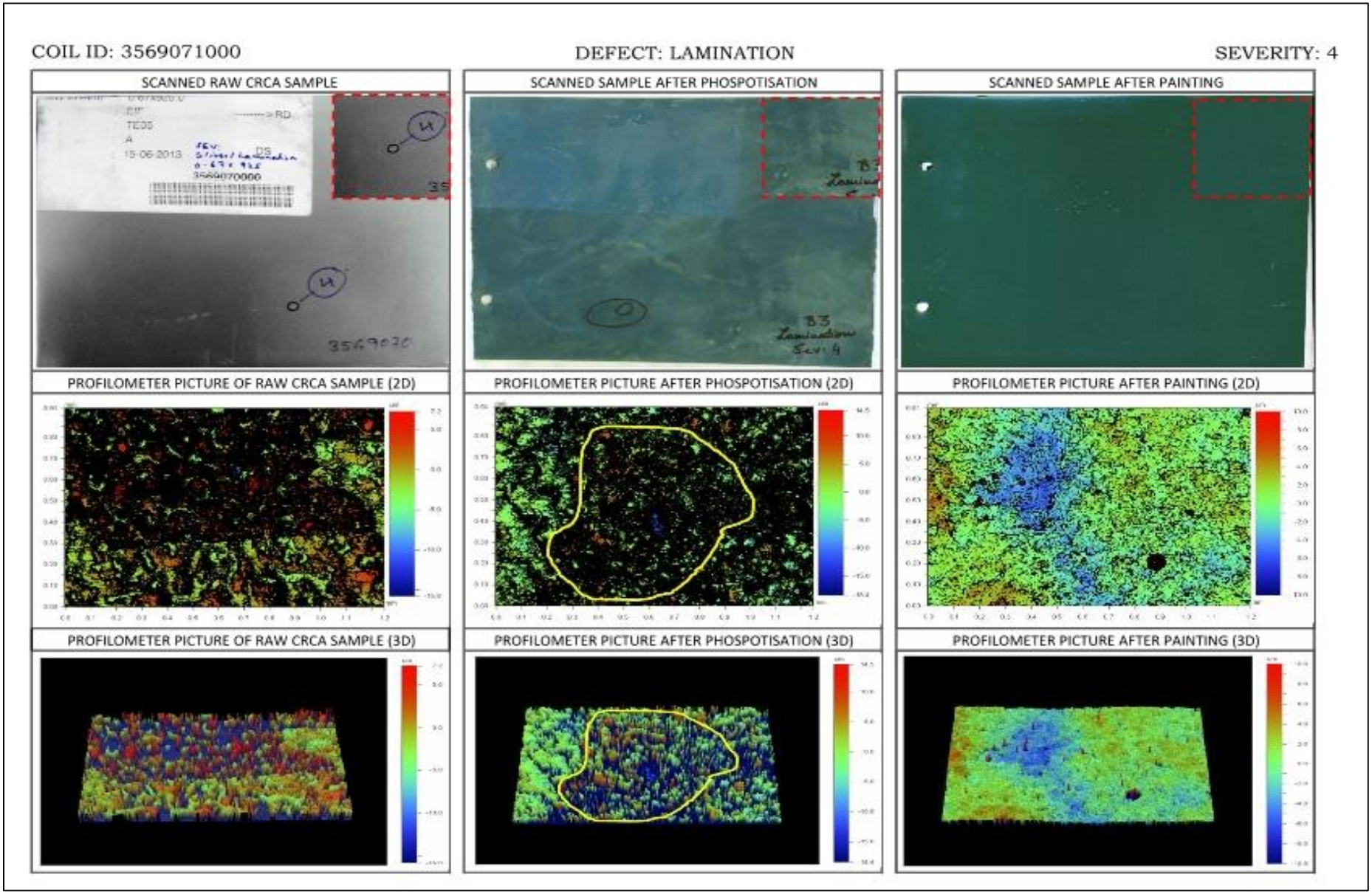
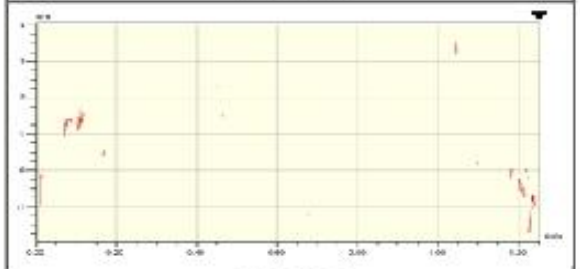
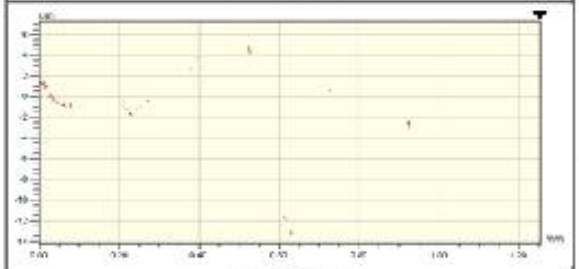
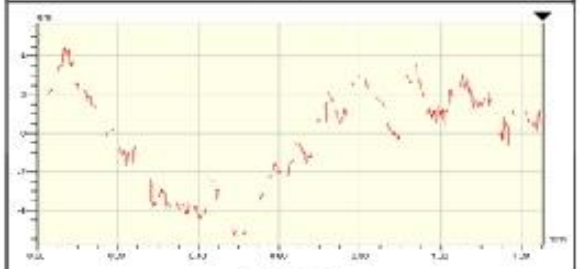
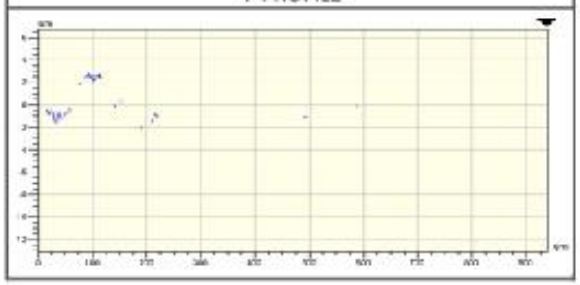
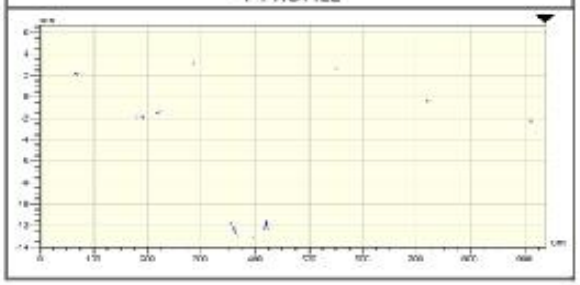
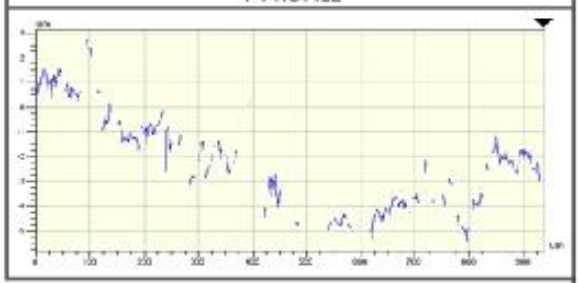

COIL ID: 3569071000
DEFECT: LAMINATION
SEVERITY: 4
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.2.1

COIL ID: 3569071000 DEFECT: LAMINATION SEVERITY: 4

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.67 mm | YIELD STRENGTH (YS): 152 Pa | ULTIMATE TENSILE STRENGTH: 299 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.50 um | DEPTH AFTER PHOSPOTISATION | 19.58 um | DEPTH AFTER PAINTING | 10.45 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Lamination of Severity 4 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 3.93 um, showing the values are incomparable to the roughness of defect after painting. |

Fig: 5.2.2

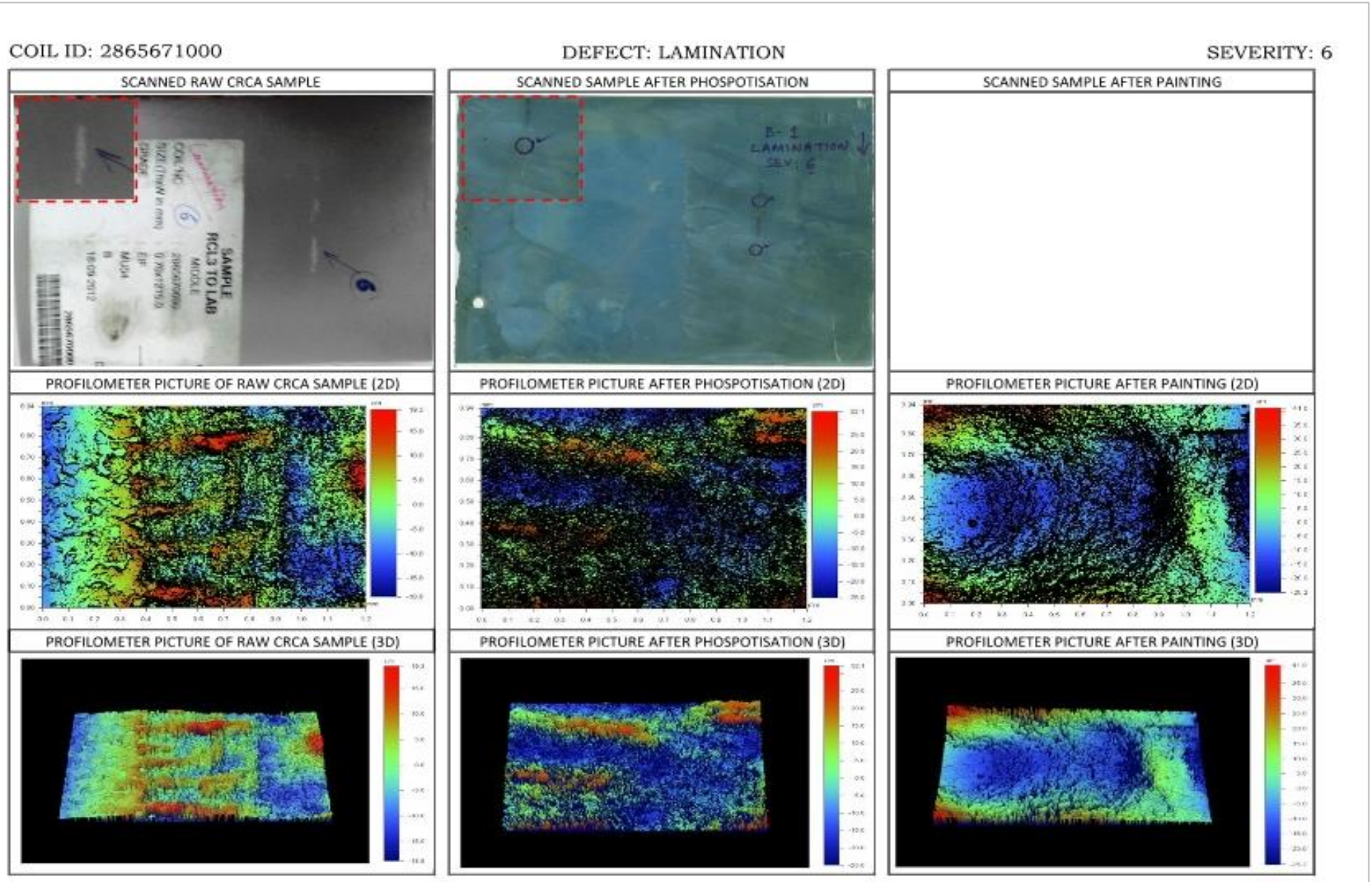
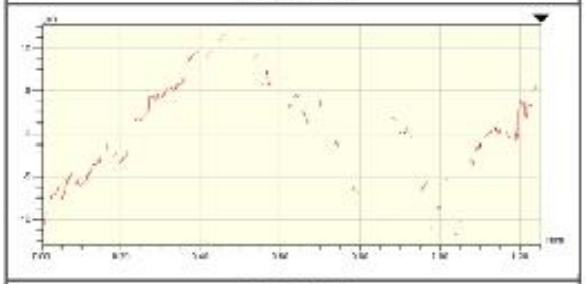
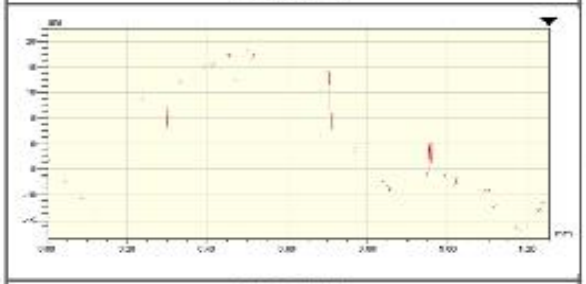
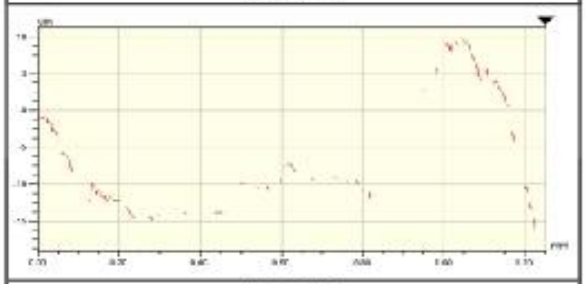
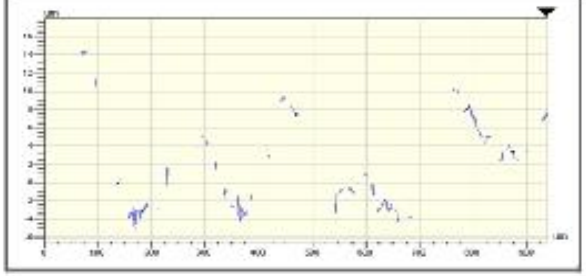
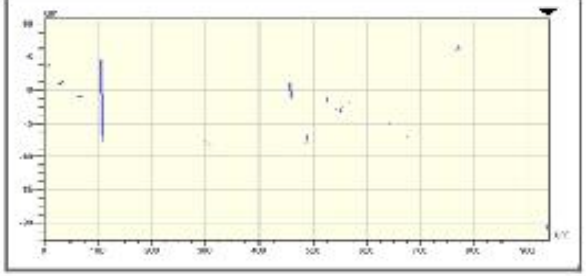
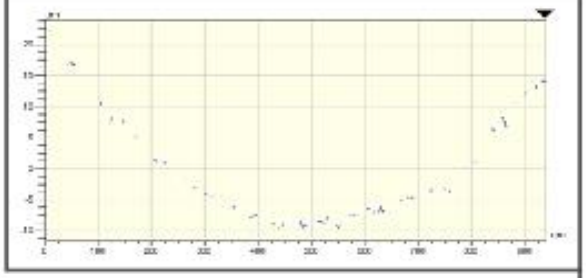

COIL ID: 2865671000
DEFECT: LAMINATION
SEVERITY: 6
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.2.3

COIL ID: 2865671000 DEFECT: LAMINATION SEVERITY: 6

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.7 mm | YIELD STRENGTH (YS): 132 Pa | ULTIMATE TENSILE STRENGTH: 292 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 23.43 um | DEPTH AFTER PHOSPOTISATION | 37.55 um | DEPTH AFTER PAINTING | 27.59 um |

| ECV SAMPLE | NOT AVAILABLE | Lamination of Severity 6 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 4.05 um, showing the values are incomparable to the roughness of defect after painting. |
|---|---|---|

Fig: 5.2.4

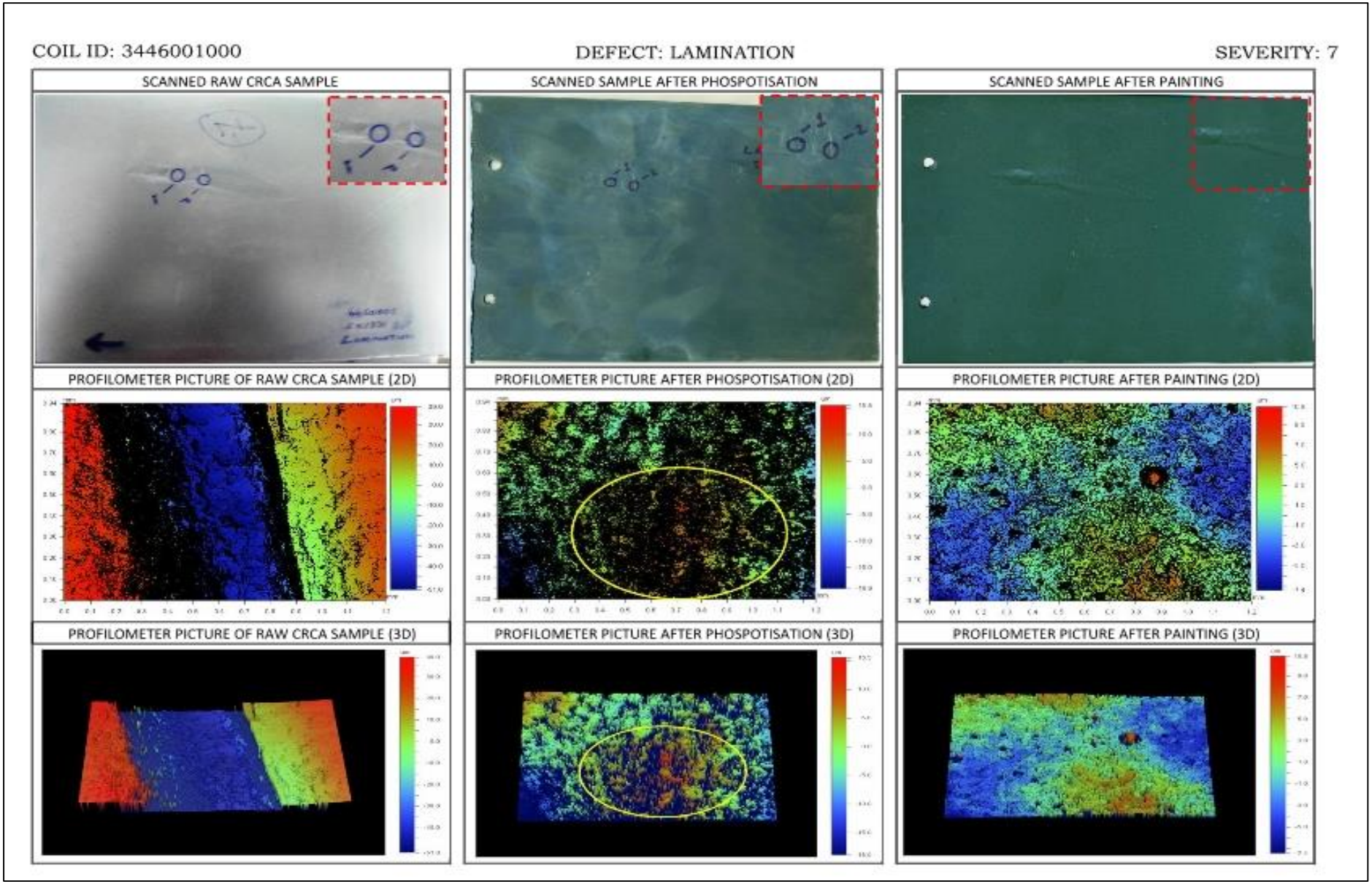
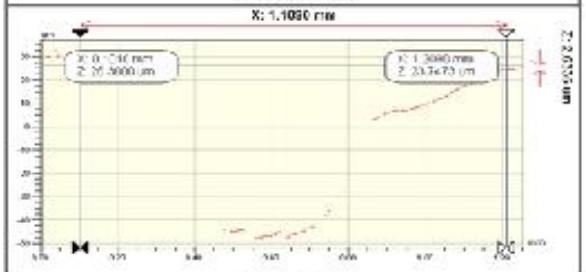
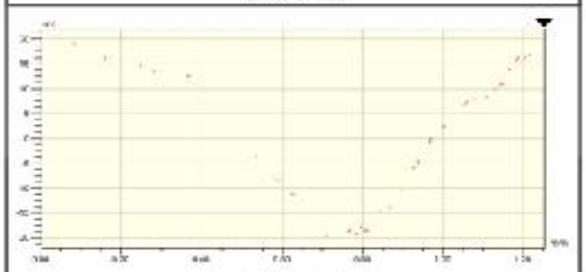
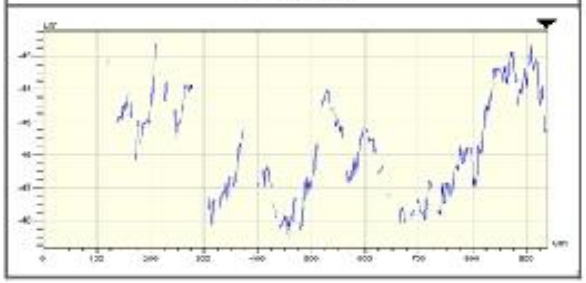
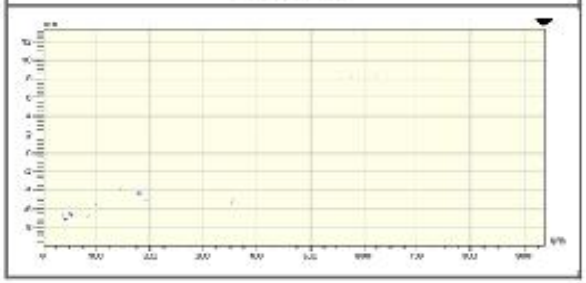
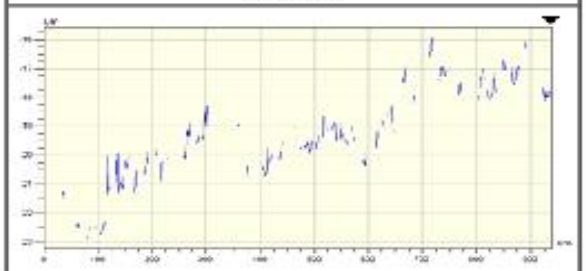

COIL ID: 3446001000
DEFECT: LAMINATION
SEVERITY: 7
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.2.5

COIL ID: 3446001000 | DEFECT: LAMINATION | SEVERITY: 7

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 1.4 mm | YIELD STRENGTH (YS): 282 Pa | ULTIMATE TENSILE STRENGTH: 374 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 74.59 um | DEPTH AFTER PHOSPOTISATION | 79.19 um | DEPTH AFTER PAINTING | 40.09 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Lamination of Severity 7 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 2.88 um, showing the values are incomparable to the roughness of defect after pain |

Fig: 5.2.6

# 5.3 | ROLL MARK/DENT

Definition

Dent is the indented condition of the strip surface with some pitch or without pitch. Depending on direction of rewinding of coil the condition of dent can be either concave or convex.

Roll Mark may be left due to defective rolls.

**Causes**

Sometimes, when the rolls are damaged (chip out) causing dents on strip at regular interval.

## SEVERITY – 2 | 3 | 4 | 5

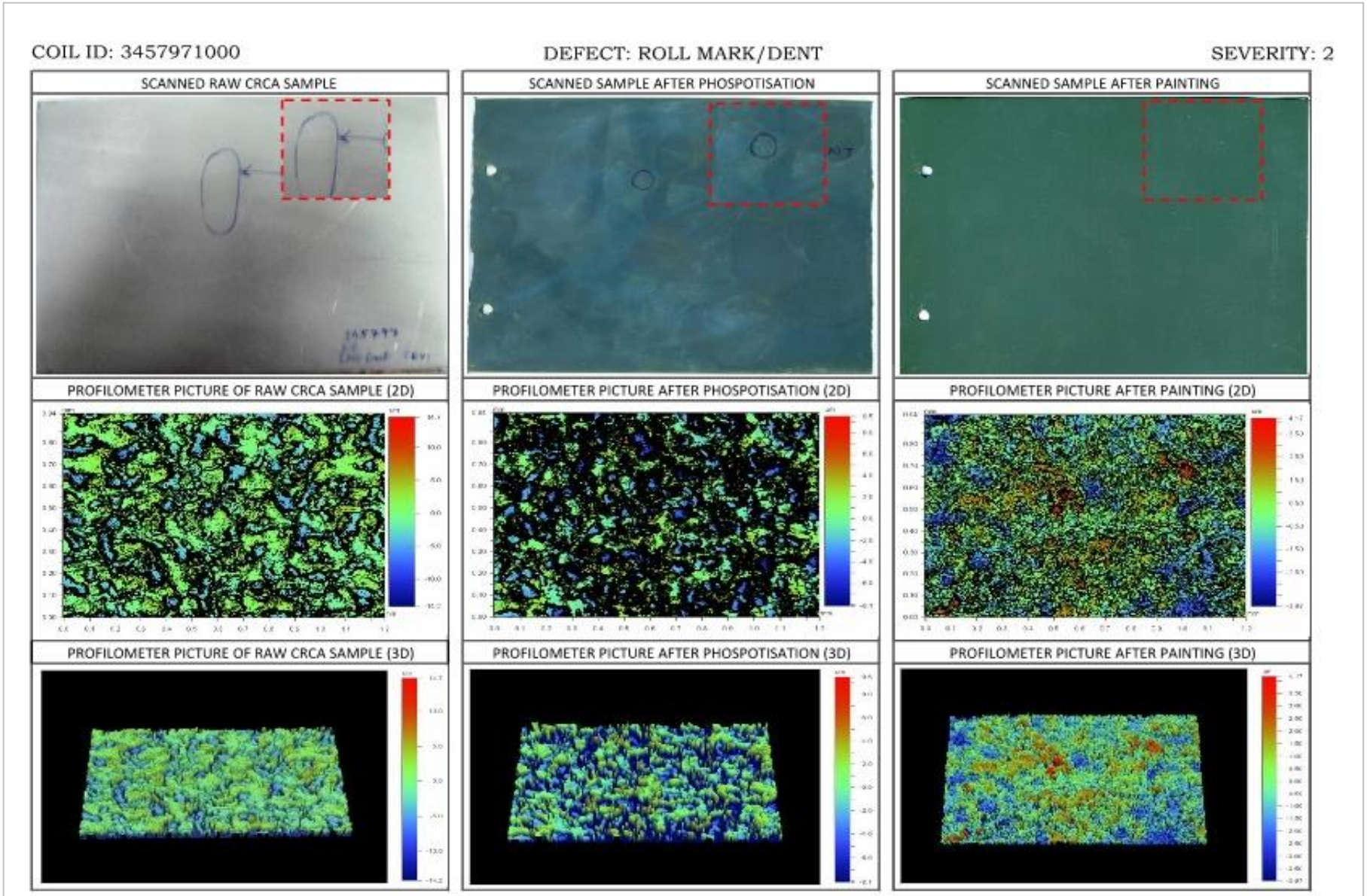
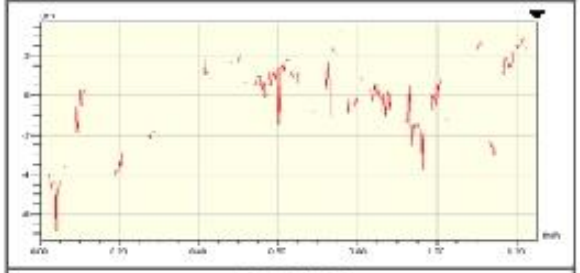
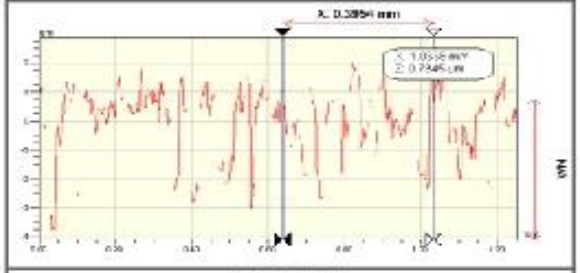
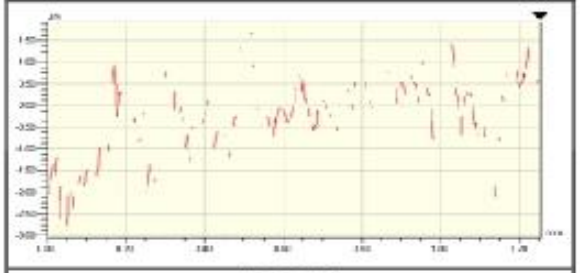
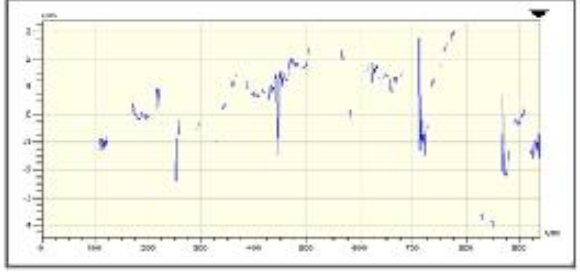
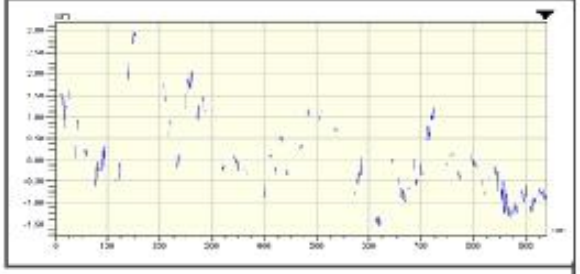

COIL ID: 3457971000
DEFECT: ROLL MARK/DENT
SEVERITY: 2
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.3.1

COIL ID: 3457971000 DEFECT: ROLL MARK/DENT SEVERITY: 2

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 1.00 mm | YIELD STRENGTH (YS): 163 Pa | ULTIMATE TENSILE STRENGTH: 293 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 3.45 um | DEPTH AFTER PHOSPOTISATION | 4.67 um | DEPTH AFTER PAINTING | 4.53 um |

ECV SAMPLE

Roll Mark/Dent of Severity 2 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect

The Roughness of the unaffected area of the sample after painting is 4.45 um, showing the values are comparable to the roughness of defect after painting.

Fig: 5.3.2

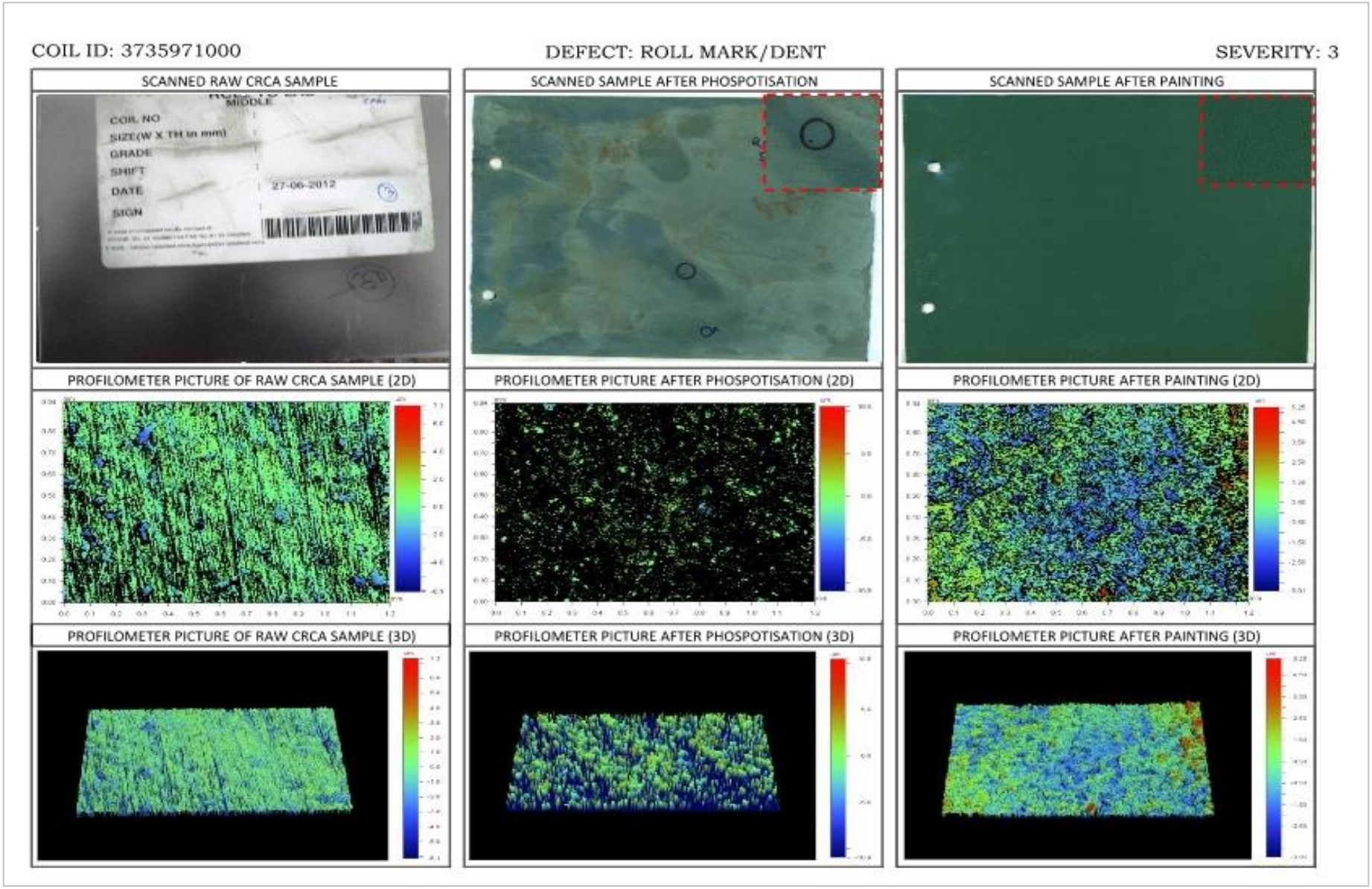
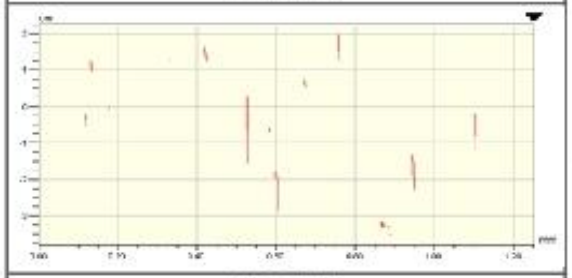
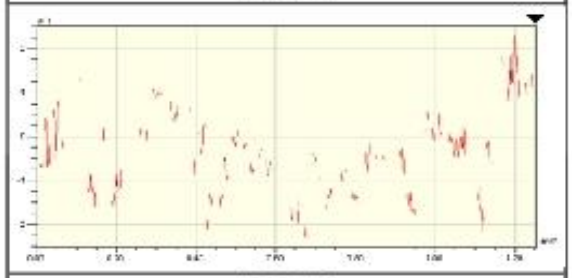
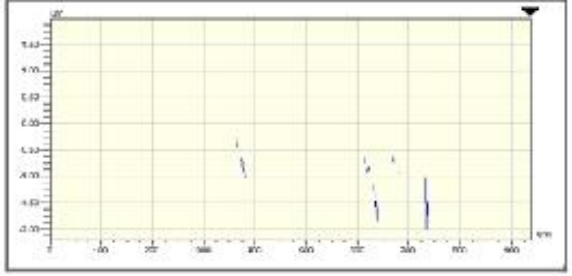
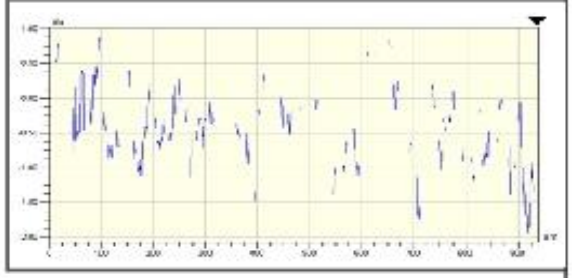

COIL ID: 3735971000
DEFECT: ROLL MARK/DENT
SEVERITY: 3
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
COIL NO
SIZE(W X TH in mm)
GRADE
SHIFT
DATE
SIGN
27-06-2012
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.3.3

COIL ID: 3735971000 | DEFECT: ROLL MARK/DENT | SEVERITY: 3

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.67 mm | YIELD STRENGTH (YS): 128 Pa | ULTIMATE TENSILE STRENGTH: 286 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 1.92 um | DEPTH AFTER PHOSPOTISATION | 5.50 um | DEPTH AFTER PAINTING | 4.58 um |

ECV SAMPLE

Roll Mark/Dent of Severity 3 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect

The Roughness of the unaffected area of the sample after painting is 4.25 um, showing the values are comparable to the roughness of defect after painting.

Fig: 5.3.4

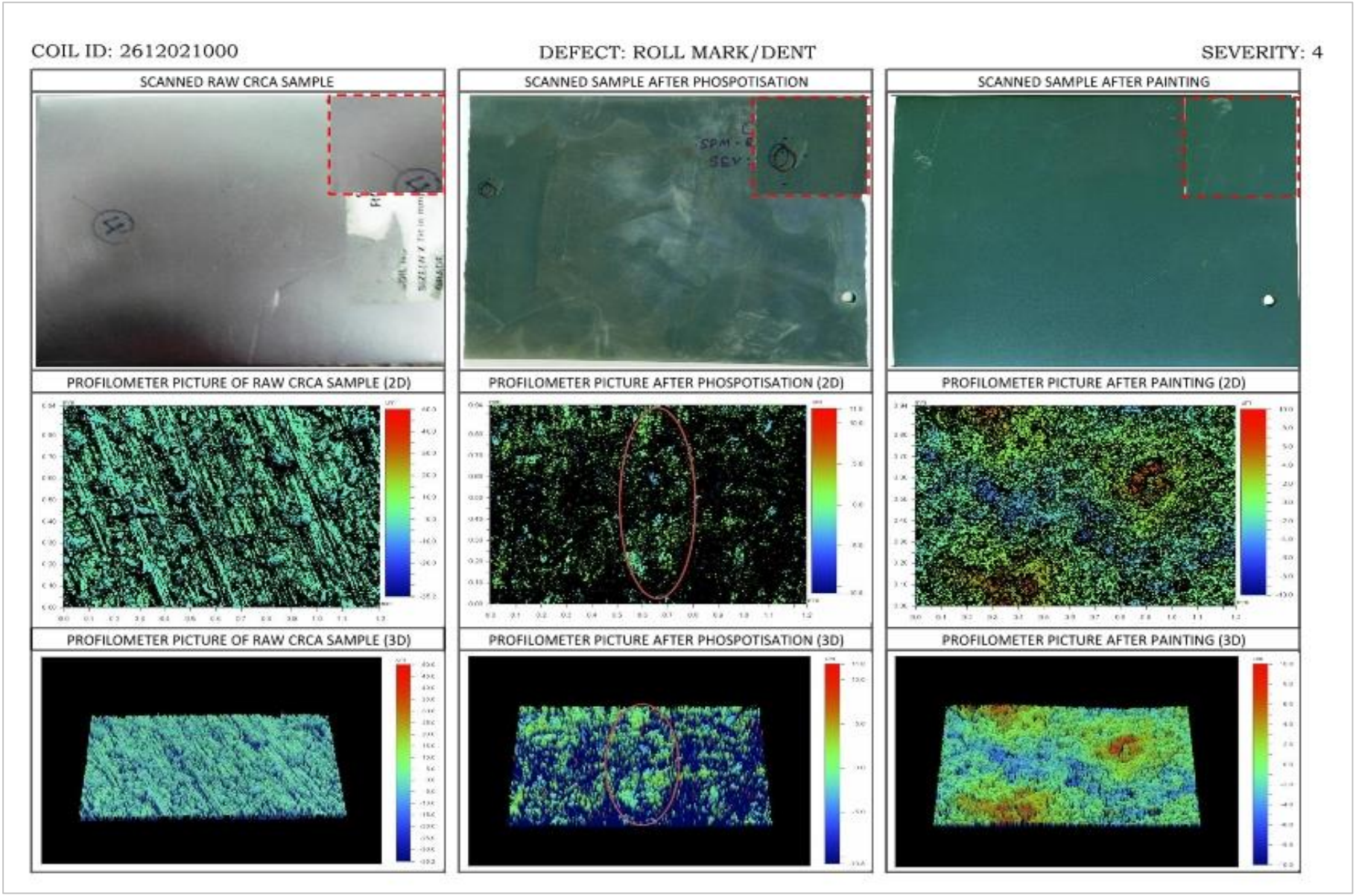
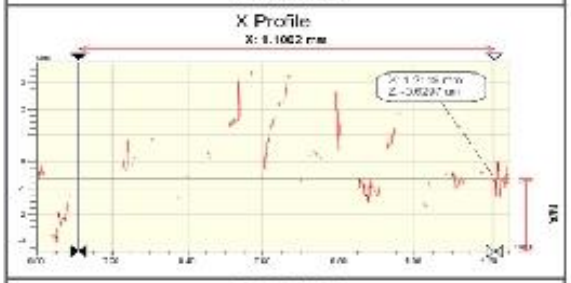
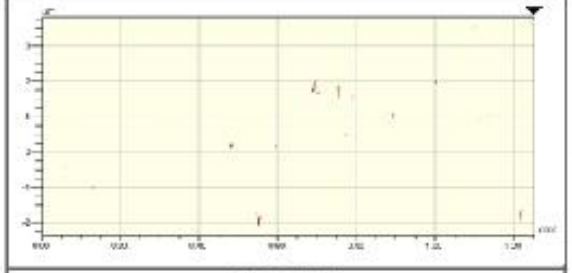
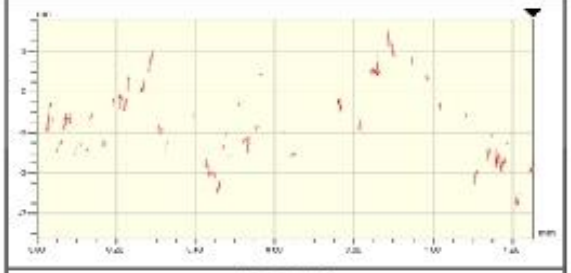
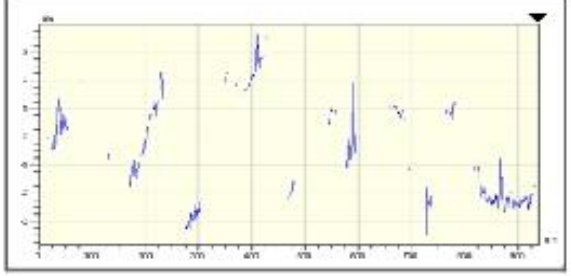
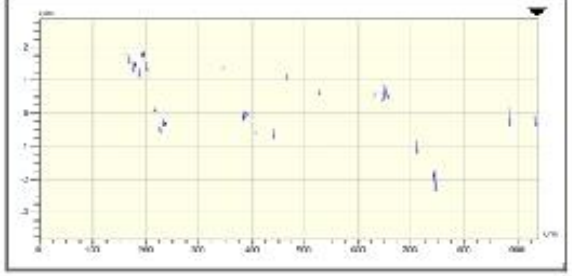
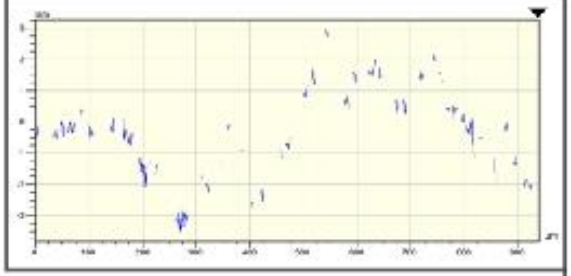

COIL ID: 2612021000
DEFECT: ROLL MARK/DENT
SEVERITY: 4
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.3.5

COIL ID: 2612021000 | DEFECT: ROLL MARK | SEVERITY: 4

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 2.30 mm | YIELD STRENGTH (YS): 137 Pa | ULTIMATE TENSILE STRENGTH: 275 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.21 um | DEPTH AFTER PHOSPOTISATION | 5.61 um | DEPTH AFTER PAINTING | 4.92 um |

ECV SAMPLE

Roll Mark/Dent of Severity 4 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect

The Roughness of the unaffected area of the sample after painting is 3.64 um, showing the values are incomparable to the roughness of defect after painting.

Fig: 5.3.6

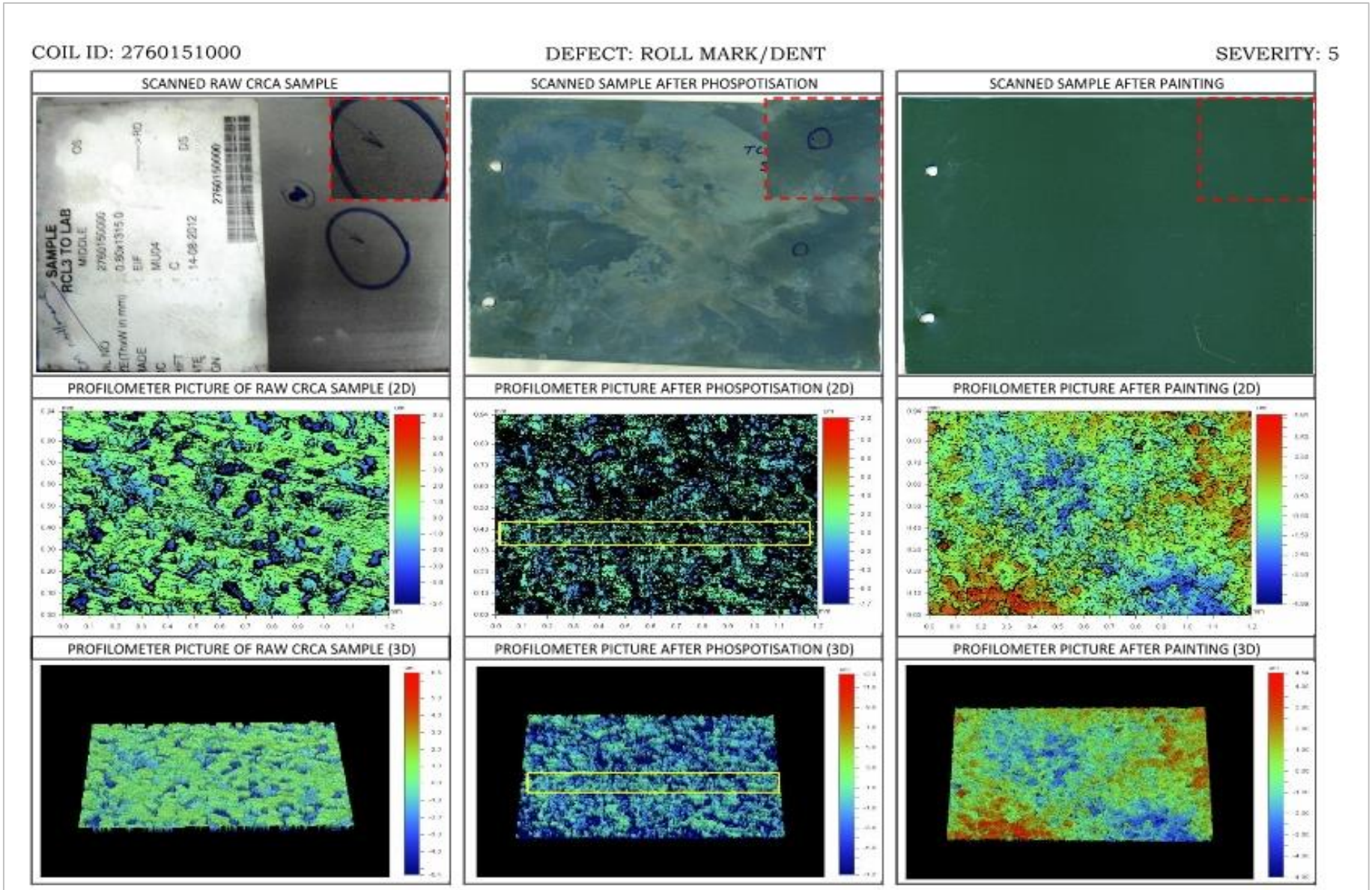
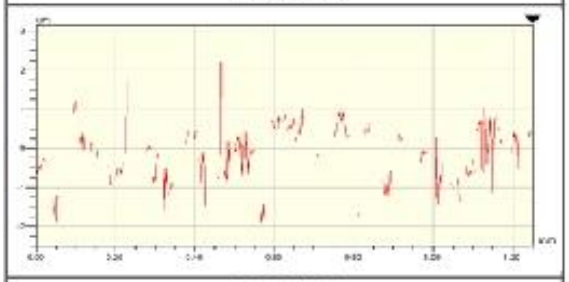
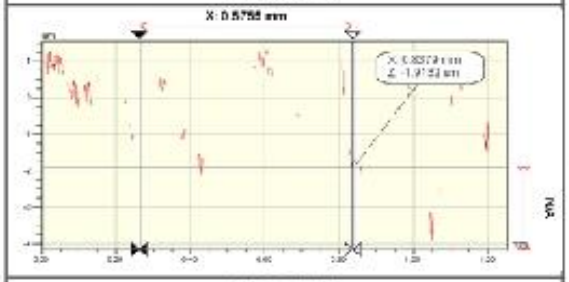
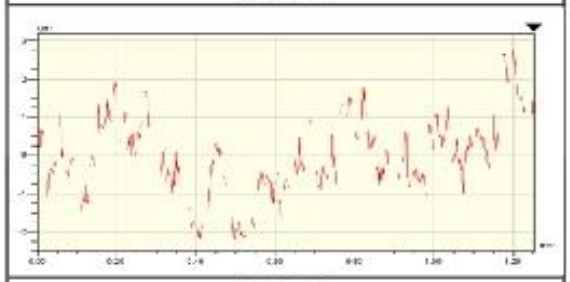
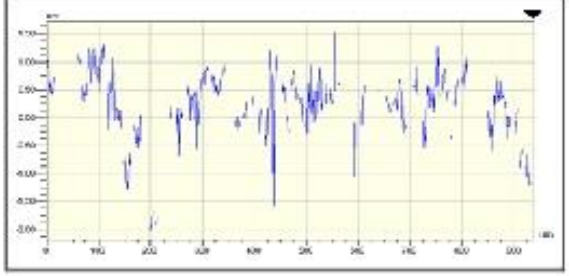
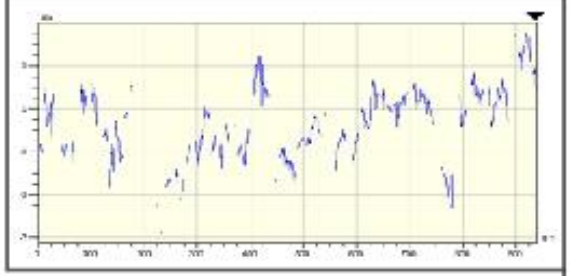

COIL ID: 2760151000
DEFECT: ROLL MARK/DENT
SEVERITY: 5
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.3.7

COIL ID: 2760151000 DEFECT: ROLL MARK SEVERITY: 5

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.8 mm | YIELD STRENGTH (YS): 135 Pa | ULTIMATE TENSILE STRENGTH: 291 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.13 um | DEPTH AFTER PHOSPOTISATION | 3.36 um | DEPTH AFTER PAINTING | 5.16 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Roll Mark/Dent of Severity 5 MAY BE OK/ NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' here is incomparable suggesting it has not covered the defect. So it can be passed based on sample.<br><br>The Roughness of the unaffected area of the sample after painting is 4.73 um, showing the values are comparable to the roughness of defect after painting. |

Fig: 5.3.8

# 5.4 | SCRATCH

Definition

During processing of cold rolled coil it passes through various processing lines. During processing if sheets gets in contact with any stationary part / equipment of the line or non-rotating roll that will lead to a scratch mark on the sheet.

## SEVERITY – 2 | 3 | 4

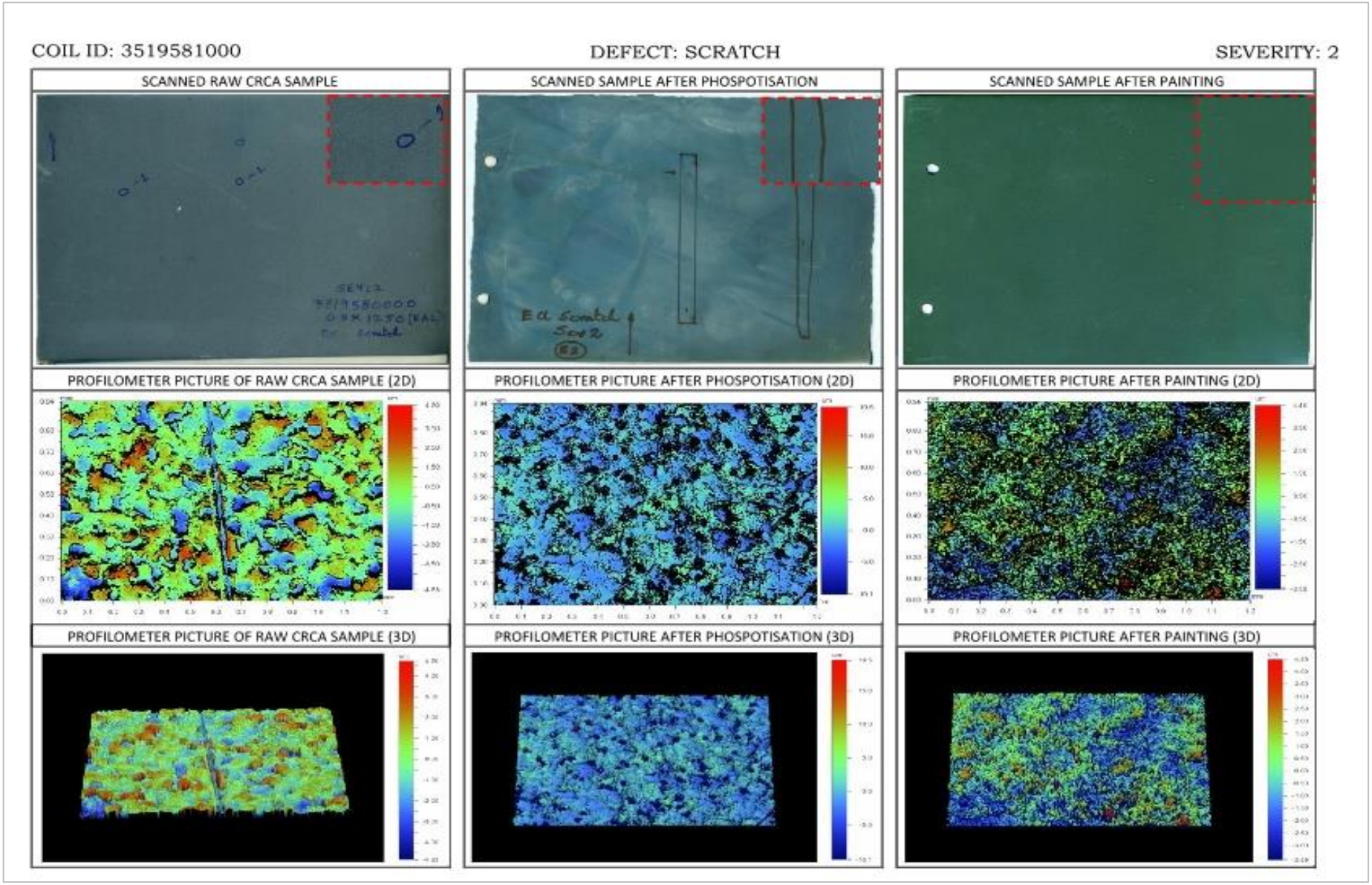
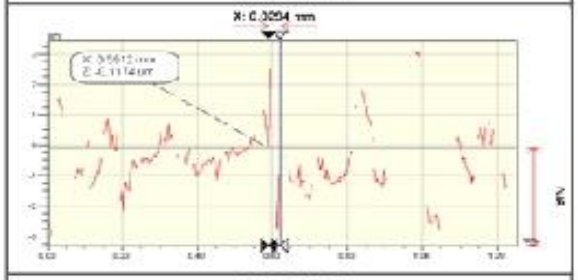
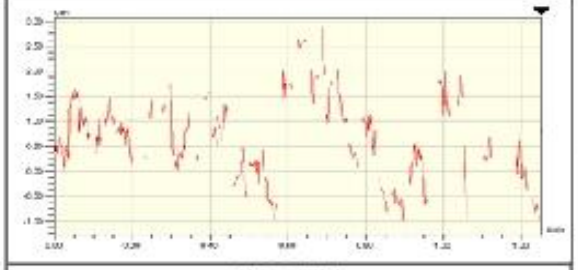
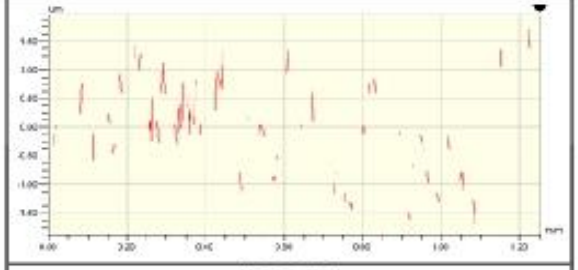
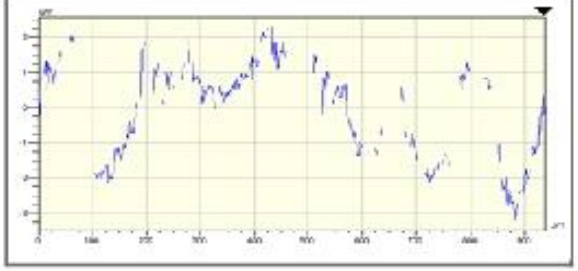
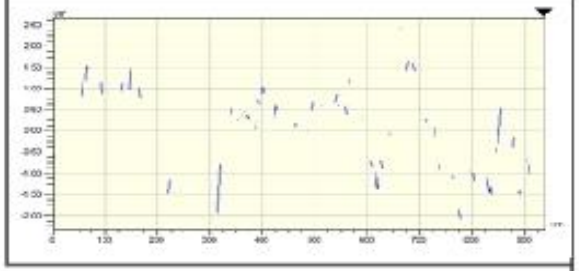

COIL ID: 3519581000
DEFECT: SCRATCH
SEVERITY: 2
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.4.1

COIL ID: 3519581000 DEFECT: SCRATCH SEVERITY: 2

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: mm | YIELD STRENGTH (YS): Pa | ULTIMATE TENSILE STRENGTH: Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 5.31 um | DEPTH AFTER PHOSPOTISATION | 3.94 um | DEPTH AFTER PAINTING | 3.50 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Scratch of Severity 2 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 3.46 um, showing the values are comparable to the roughness of defect after painting. |

Fig: 5.4.2

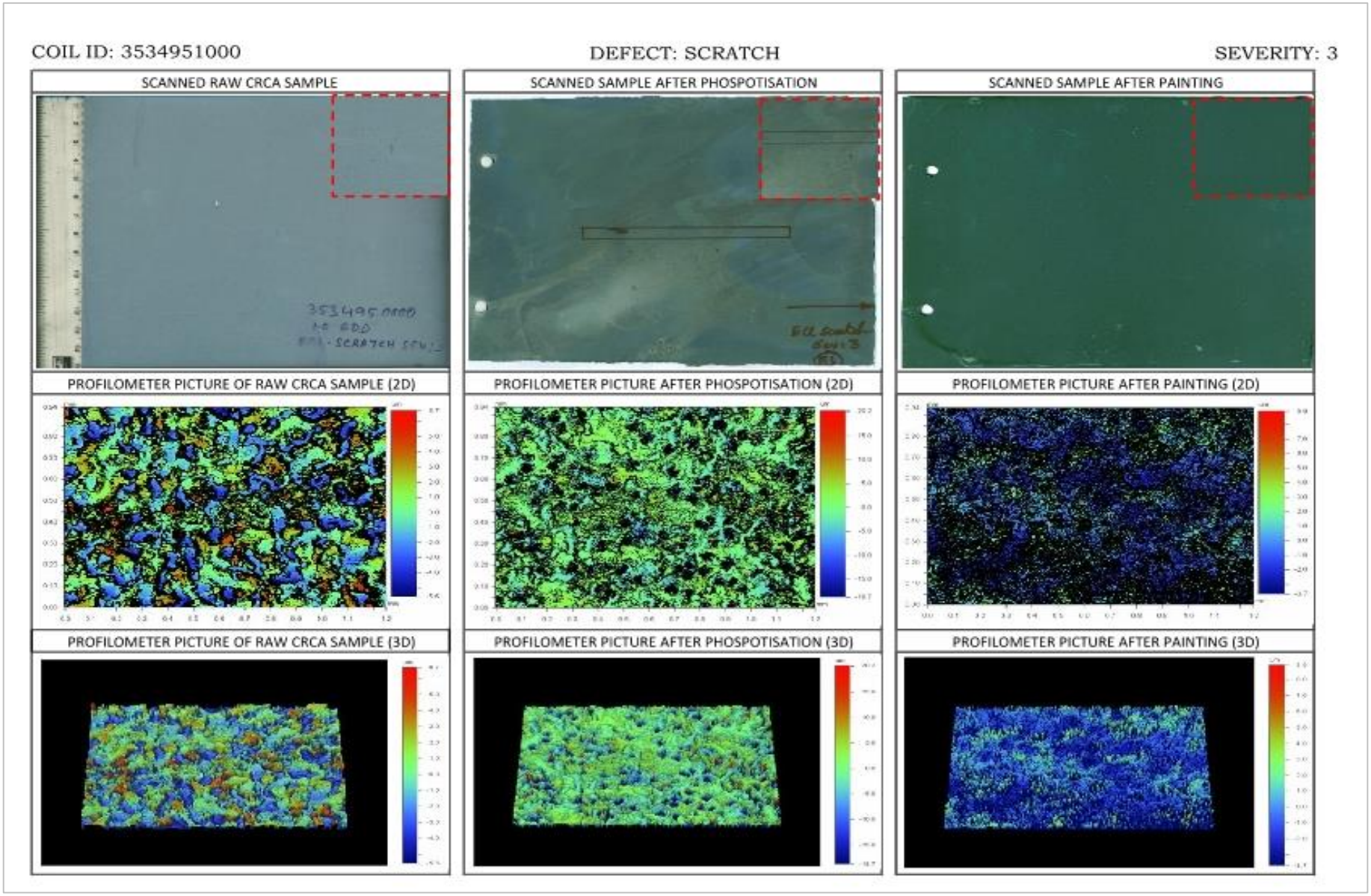
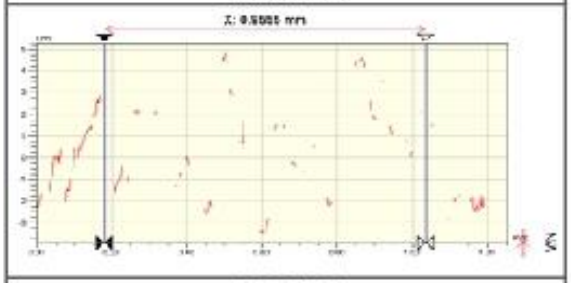
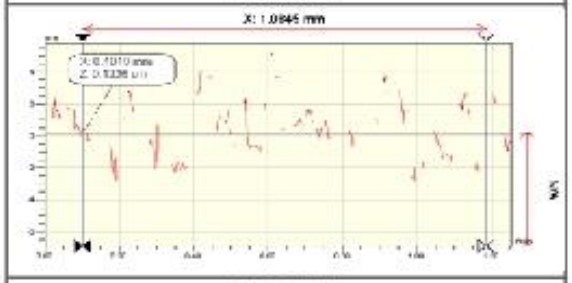
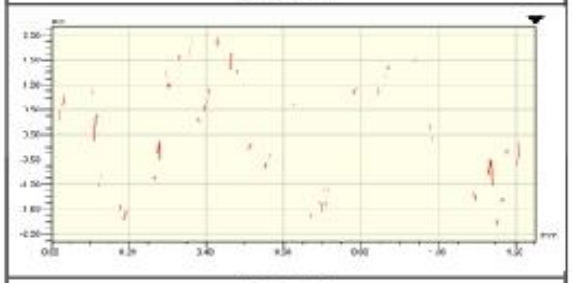
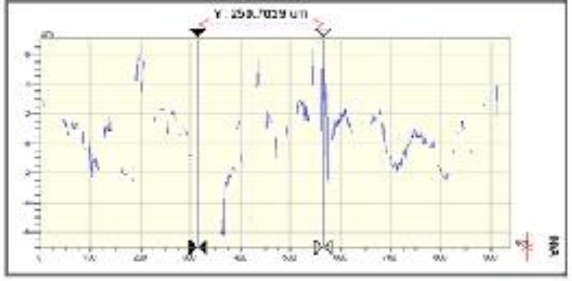
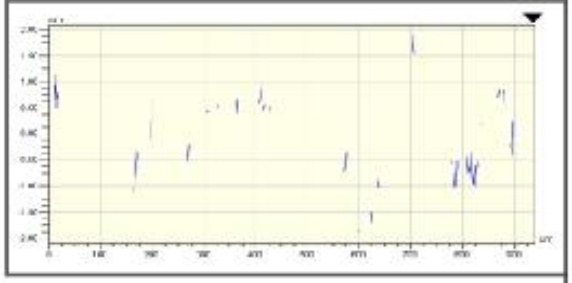

COIL ID: 3534951000
DEFECT: SCRATCH
SEVERITY: 3
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.4.3

COIL ID: 3534951000 DEFECT: SCRATCH SEVERITY: 3

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |

| THICKNESS: 1.00 mm | YIELD STRENGTH (YS): 147 Pa | ULTIMATE TENSILE STRENGTH: 284 Pa |
|---|---|---|

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

CONCLUSION

| DEPTH BEFORE PHOSPOTISATION | 8.34 um | DEPTH AFTER PHOSPOTISATION | 11.54 um | DEPTH AFTER PAINTING | 3.92 um |
|---|---|---|---|---|---|

| ECV SAMPLE | NOT AVAILABLE | Scratch of Severity 3 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 3.81 um, showing the values are comparable to the roughness of defect after painting. |
|---|---|---|

Fig: 5.4.4

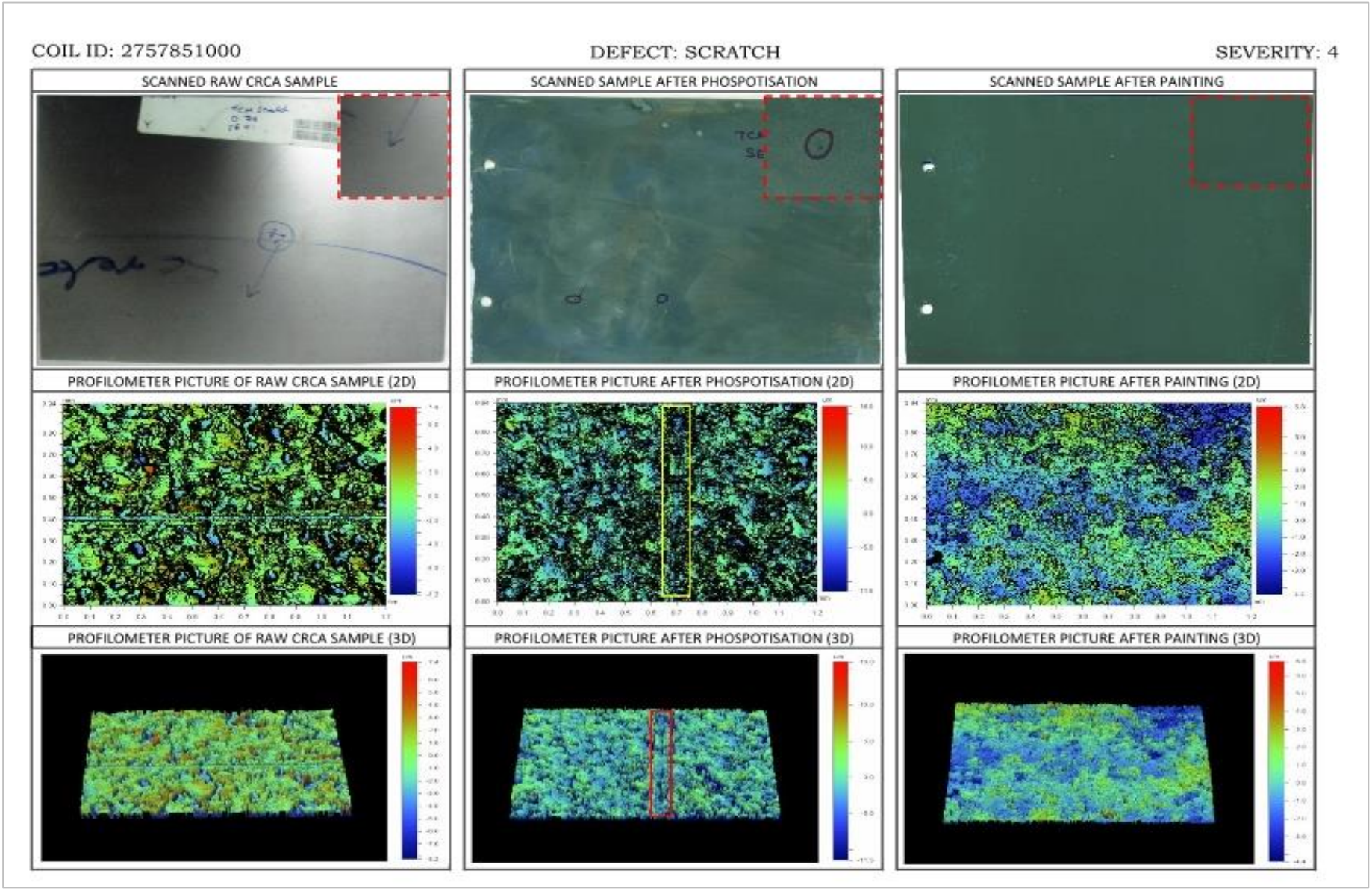
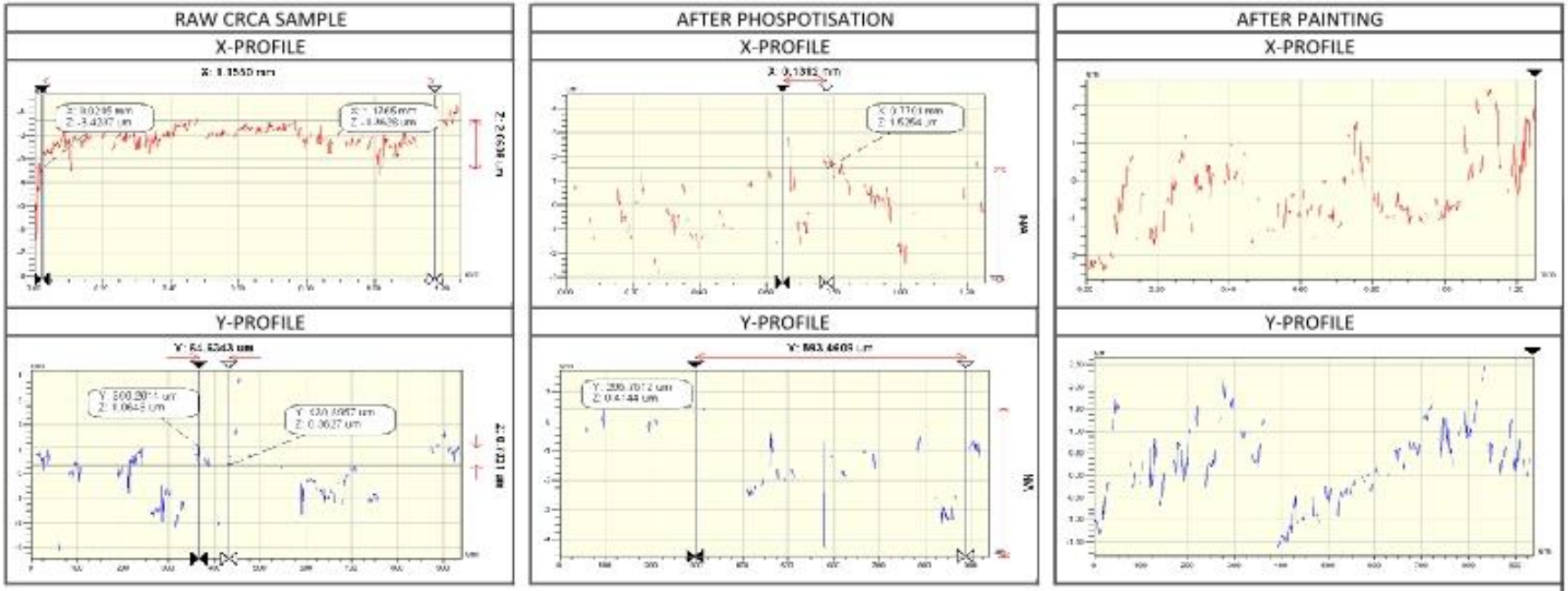

COIL ID: 2757851000
DEFECT: SCRATCH
SEVERITY: 4
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.4.5

COIL ID: 2757851000 DEFECT: SCRATCH SEVERITY: 4




| THICKNESS: 0.70 mm | YIELD STRENGTH (YS): 145 Pa | ULTIMATE TENSILE STRENGTH: 299 Pa |
|---|---|---|

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 4.35 um | DEPTH AFTER PHOSPOTISATION | 4.43 um | DEPTH AFTER PAINTING | 4.86 um |

ECV SAMPLE

Scratch of Severity 4 is OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is comparable suggesting it has covered the defect

The Roughness of the unaffected area of the sample after painting is 4.72 um, showing the values are comparable to the roughness of defect after painting.

Fig: 5.4.6

# 5.5 | GOUGE MARK

Definition

This erupts in rolling direction. Some are pit type and others appear only as surface pattern, relatively long (Slip scratches). Mostly these are hot strip scratches of various dimensions and sometimes it undergoes a small degree of over rolling / lapping. If the strip is damaged in its hot condition, the defect undergoes scaling and may be rolled closed.

**Causes:-**

i. This defect is caused by Hot Mill guide device, etc. is rolled down for less depth and discoloured to dull appearance.

ii. This defect also caused by guide device at Pickling or Cold Rolling Process.

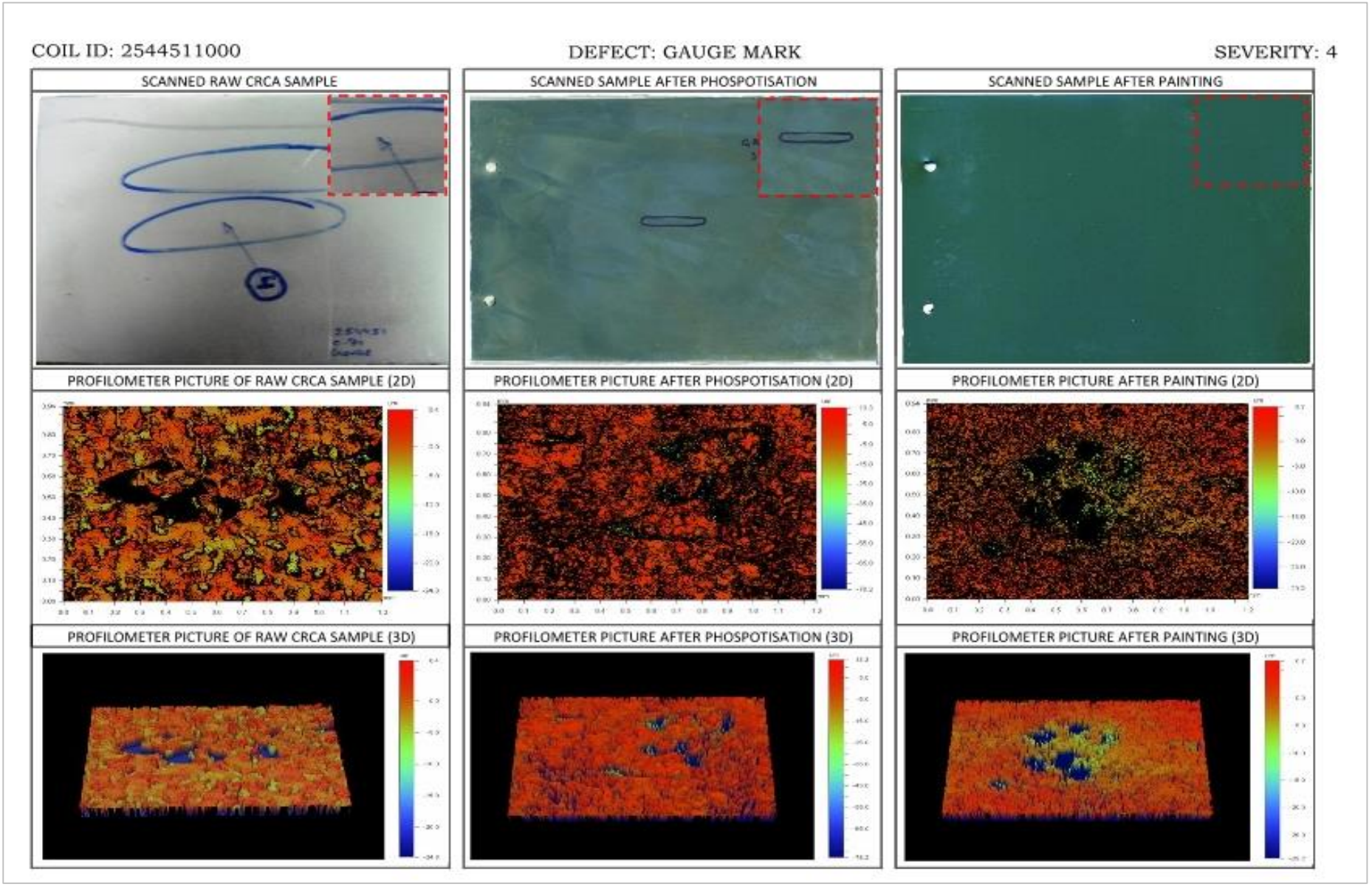
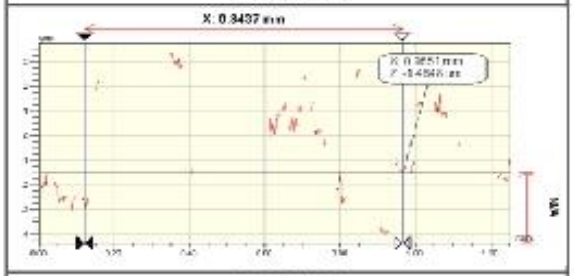
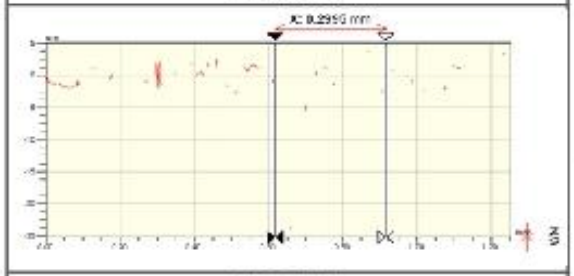
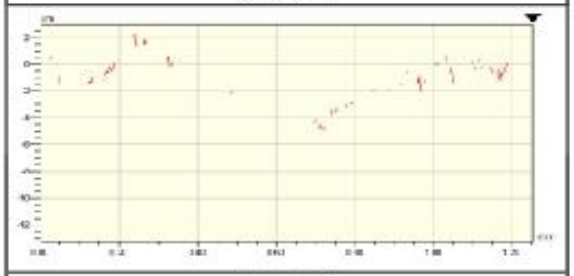
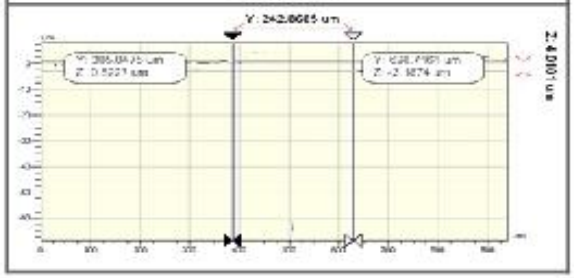
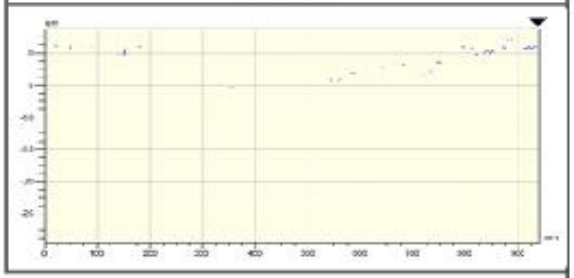

COIL ID: 2544511000
DEFECT: GAUGE MARK
SEVERITY: 4
SCANNED RAW CRCA SAMPLE
SCANNED SAMPLE AFTER PHOSPOTISATION
SCANNED SAMPLE AFTER PAINTING
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (2D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (2D)
PROFILOMETER PICTURE AFTER PAINTING (2D)
PROFILOMETER PICTURE OF RAW CRCA SAMPLE (3D)
PROFILOMETER PICTURE AFTER PHOSPOTISATION (3D)
PROFILOMETER PICTURE AFTER PAINTING (3D)

Fig: 5.5.1

COIL ID: 2544511000 DEFECT: GAUGE MARK SEVERITY: 4

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.70 mm | YIELD STRENGTH (YS): 136 Pa | ULTIMATE TENSILE STRENGTH: 293 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 7.37 um | DEPTH AFTER PHOSPOTISATION | 27.58 um | DEPTH AFTER PAINTING | 14.73 um |

| | | |
|---|---|---|
| ECV SAMPLE | NOT AVAILABLE | Gauge Mark of Severity 4 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 4.99 um, showing the values are comparable to the roughness of defect after painting. |

Fig: 5.5.2

COIL ID: 3572451000 DEFECT: GAUGE MARK SEVERITY: 6

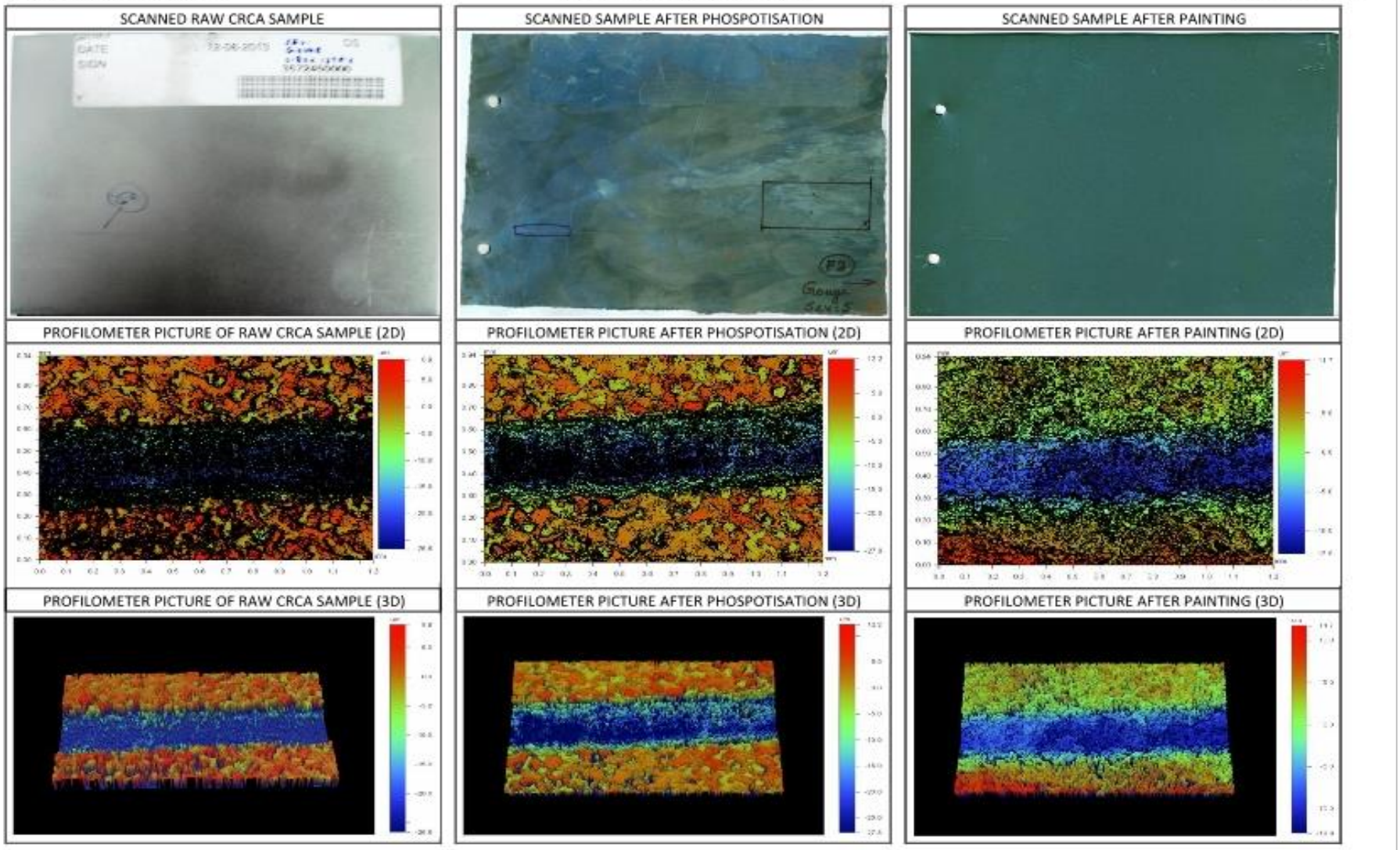
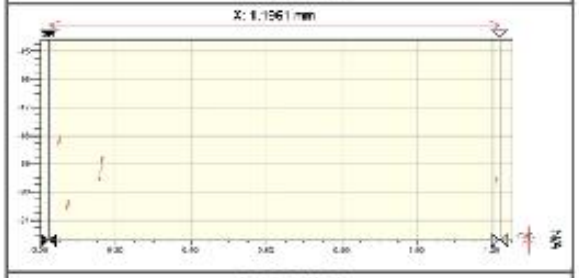
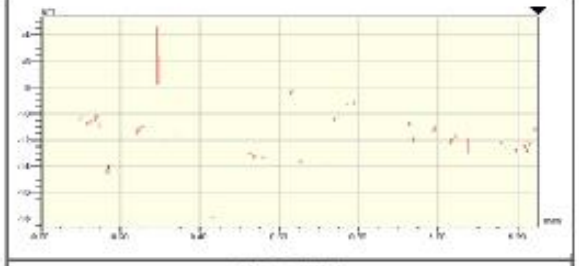
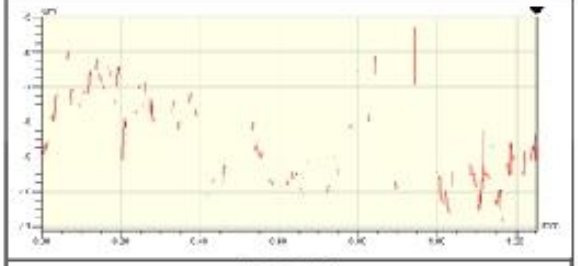
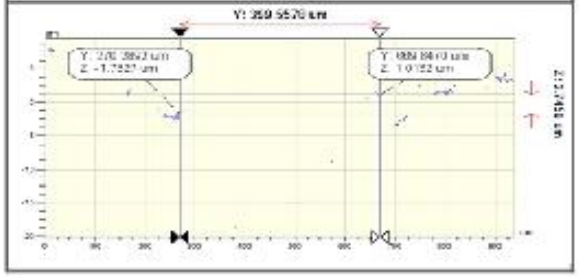
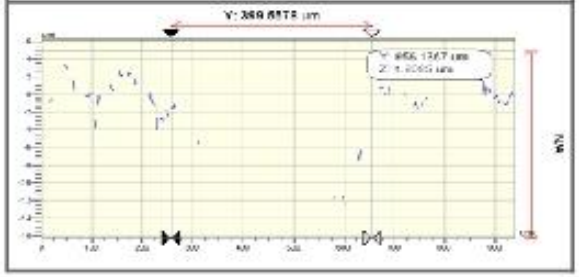
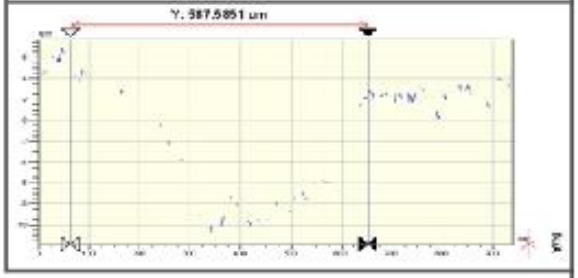



Fig: 5.5.3

COIL ID: 3572451000 DEFECT: GAUGE MARK SEVERITY: 6

| RAW CRCA SAMPLE | AFTER PHOSPOTISATION | AFTER PAINTING |
|---|---|---|
| X-PROFILE | X-PROFILE | X-PROFILE |
|  |  |  |
| Y-PROFILE | Y-PROFILE | Y-PROFILE |
|  |  |  |
| THICKNESS: 0.80 mm | YIELD STRENGTH (YS): 161 Pa | ULTIMATE TENSILE STRENGTH: 295 Pa |

PHOSPATING THICKNESS: 1-2 um, DRY FILM THICKNESS: 30 um for SPRAY PAINTING

| CONCLUSION | | | | | |
|---|---|---|---|---|---|
| DEPTH BEFORE PHOSPOTISATION | 36.31 um | DEPTH AFTER PHOSPOTISATION | 21.21 um | DEPTH AFTER PAINTING | 16.12 um |

| ECV SAMPLE | NOT AVAILABLE | Gauge Mark of Severity 6 is NOT OK for skin panel application.The 'depth of the defect after painting' and 'normal profile of the painted non-defected area' is incomparable suggesting it has not covered the defect<br><br>The Roughness of the unaffected area of the sample after painting is 4.68 um, showing the values are comparable to the roughness of defect after painting. |
|---|---|---|

Fig: 5.5.4

## 6 | RESULT AND DISCUSSION

The following table gives an overall picture to the experiments carried out above

| | | Roughness | | | Rp (Peak) | | | Rv (Valley) | | | Rt [(Total) = (Peak+Valley)] | | | Rt: AFTER PAINT (GENERAL SURFACE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEFECT | SEV | BEFORE | AFTER | AFTER PAINT | BEFORE | AFTER | AFTER PAINT | BEFORE | AFTER | AFTER PAINT | BEFORE | AFTER | AFTER PAINT | |
| MATTLESS SPOT | 2 | 0.72 | 0.58 | 0.65 | 1.72 | 1.63 | 1.76 | 2.99 | 0.87 | 1.95 | 4.72 | 2.49 | 3.71 | 3.45 |
| MATTLESS SPOT | 3 | 0.72 | 0.82 | 0.48 | 1.98 | 1.54 | 1.71 | 2.40 | 1.87 | 0.54 | 4.38 | 3.37 | 2.25 | 2.88 |
| MATTLESS SPOT | 4 | 0.60 | 0.53 | 0.59 | 2.20 | 1.96 | 1.47 | 2.10 | 4.13 | 1.57 | 4.30 | 6.09 | 3.04 | 2.88 |
| MATTLESS SPOT | 5 | 0.79 | 1.00 | 0.64 | 2.22 | 2.63 | 1.57 | 3.49 | 3.25 | 1.25 | 5.70 | 5.88 | 2.82 | 2.80 |
| | | | | | | | | | | | | | | |
| LAMINATION | 4 | 1.04 | 2.02 | 2.10 | 3.80 | 6.24 | 5.17 | 1.70 | 13.31 | 5.28 | 5.50 | 19.58 | 10.45 | 3.93 |
| LAMINATION | 6 | 4.65 | 10.15 | 6.89 | 11.53 | 20.71 | 9.85 | 11.90 | 16.84 | 17.74 | 23.43 | 37.55 | 27.59 | 4.05 |
| LAMINATION | 7 | 26.78 | 19.08 | 12.64 | 26.74 | 42.28 | 19.92 | 47.85 | 36.91 | 20.17 | 74.59 | 79.19 | 40.09 | 4.33 |
| | | | | | | | | | | | | | | |
| ROLL MARK/Dent | 2 | 0.88 | 1.08 | 0.70 | 2.24 | 3.36 | 1.69 | 2.21 | 5.71 | 2.84 | 3.45 | 4.67 | 4.53 | 4.45 |
| ROLL MARK/Dent | 3 | 0.35 | 1.39 | 0.72 | 1.07 | 1.97 | 2.29 | 0.85 | 3.54 | 2.29 | 1.92 | 5.50 | 4.58 | 4.25 |
| ROLL MARK/Dent | 4 | 0.91 | 1.12 | 0.82 | 3.42 | 3.35 | 1.54 | 1.79 | 2.08 | 3.38 | 5.21 | 5.61 | 4.92 | 3.64 |
| ROLL MARK/Dent | 5 | 0.59 | 0.94 | 0.78 | 2.87 | 1.28 | 2.92 | 2.25 | 2.07 | 2.24 | 5.13 | 3.36 | 5.16 | 4.73 |
| | | | | | | | | | | | | | | |
| SCRATCH | 2 | 1.26 | 0.65 | 0.61 | 2.49 | 2.86 | 1.78 | 2.81 | 1.08 | 1.72 | 5.31 | 3.94 | 3.50 | 3.46 |
| SCRATCH | 3 | 1.88 | 1.49 | 0.99 | 4.83 | 5.20 | 1.97 | 3.51 | 6.34 | 1.95 | 8.34 | 11.54 | 3.92 | 3.81 |
| SCRATCH | 4 | 0.32 | 1.22 | 0.81 | 2.29 | 2.74 | 2.46 | 2.06 | 1.69 | 2.40 | 4.35 | 4.43 | 4.86 | 4.72 |
| | | | | | | | | | | | | | | |
| GAUGE MARK | 4 | 1.60 | 14.14 | 1.54 | 3.38 | 3.69 | 2.20 | 4.00 | 23.90 | 12.53 | 7.37 | 27.58 | 14.73 | 4.99 |
| GAUGE MARK | 6 | 1.28 | 1.56 | 1.09 | 14.92 | 3.34 | 5.27 | 21.39 | 17.87 | 10.85 | 36.31 | 21.21 | 16.12 | 4.68 |

Fig 6.1: Profilometer analysis of the Defected - Raw CRCA sample, Phospotised CRCA, After Paint CRCA; General Surface (After paint) sample. Note: All numerical figures are in micrometer.

The defects encountered were Mattless Spot, Lamination, Roll Mark/ Dent, Scratch & Gauge Mark. The Scratch defects includes ECL, TCM, SPM & RCL. The ECL scratch was approximately 2 micrometer higher than other types of scratch and so were considered together.

The criteria for selection or rejection of sample depends on its comparable thickness. This comparable thickness is the thickness of the defected area and that of non-defected area of the same sample.

Profilometer test were also carried for in-market auto component sample. The total roughness was in the order of 0.5 – 1.0 micron and average roughness being 0.05 – 0.15 microns. The average thickness of the combination of Phosphate, ED and 2-3 Layers of Paint accounts for 100-130 microns thickness for different automobile manufacturer.

In general the Total Roughness Rt, varied within 2.5 – 5.0 microns for the defected area and Average Roughness Ra, varied within 0.5 – 1.2 microns.

Based on the Fig: 7.1, we can list down the severity of individual defects that can be passed or rejected.

| SEVERITY | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| DEFECTS | | | | | | | |
| MATTLESS SPOT | ✓ | ✓ | ✓ | ✓ | ✓ | NA | NA |
| LAMINATION | NA | NA | NA | ✗ | ✗ | ✗ | ✗ |
| ROLL MARK/DENT | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ |
| SCRATCH (ECL, TCM, SPM, RCL) | ✓ | ✓ | ✓ | ✓ | NA | NA | NA |
| GAUGE MARK | NA | NA | NA | ✗ | ✗ | ✗ | ✗ |

| INDEX | | |
|---|---|---|
| ✓ **CAN BE PASSED** | ✗ CANNOT BE PASSED | NA NOT AVAILABLE |

Fig 6.2

## 7 | CONCLUSION

This study has made a detailed profilometer analysis of defected CRCA Stainless Steel obtained from SPM, ECL, RCL, PLTCM, LD2, HSM samples in its Raw, Phospotised, and Painted form. The quantification of qualitative defects throws a new dimension and some important conclusions drawn from the results presented here are:

1. Mattless Spot up to 5 Severity range can be passed. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 0.2 – 0.5 µm.
2. Lamination with the severity range of 4-7 cannot be passed. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 5 - 40 µm.
3. Roll Mark/Dent up to 3 Severity can be passed. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 0.25 – 1.5 µm.
4. Scratch up to 4 Severity can be passed. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 0.2 – 0.4 µm.
5. Gouge Mark from Severity 4-7 cannot be passed. The difference in total roughness obtained between defected and non-defected area after 1$^{st}$ layer of painting was the order of 8 – 10 µm.

## 8| REFERENCES


1. Center for Engineering and Physical Science Research, Columbia University; http://www.clean.cise.columbia.edu/equipment/equipmentlist/122-wyko-nt9100-profiler
2. Improved surface quality of exposed automotive steels by J. G. Speer, D. K. Matlock, N. Myers, and Y. M. Choi; October 10, 2002